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ON PSAMMICHNITES AND THE EARLY TRILOBITES OF THE CAMBRIAN ROCKS IN EASTERN CANADA.

BY G. F. MATTHEW.

In this part of the continent there are several series[1] of rocks which may properly be referred to the Cambrian system.

The following article refers to two of these and describes some of the most noticeable features of their faunas.

A. Etchiminian Series.

This the oldest of these series is not known to have any trilobites; nor have animals of this order been found in the rocks which in Wales and Norway are supposed to be of equivalent age. Throughout its whole thickness organic remains are scanty, or are so small, or obscure, as not to be readily observed. In traversing the outcrops of its measures one is at times arrested by the abundance of worm burrows, casts and tracks, indicating the existence of abundant life of a certain kind. These tracks and casts are found in the very oldest beds which are capable of preserving the imprint of organic remains; they occur in sandstones and shales immediately above the conglomerate at the base of the series. This conglomerate, about 60 feet thick, rests upon amygdaloidal greenstones, which in the report of the geological survey of Canada are referred to the Huronian system.

About two hundred feet higher in the series there are fine

[1] By this term the writer designates the grand divisions of a geological system marked by a distinctive fauna and usually separated from the series above and below by unconformities. Thus there are in this region 3 series of Cambrian rocks, 2 of Ordovician, 1 of Silurian, 2 of Devonian, 3 of Carboniferous.

branching organisms resembling seaweed and about one hundred feet higher a remarkable track occurs which is also found in the oldest Cambrian rocks of Sweden. This was named by Dr. Otto Torell *Arenicolites gigas*, which name he afterward changed to *Psammichnites gigas*. Although he at first thought this track to have been made by a worm he afterward demurred to the absolute reference of such trails to the Annelida, remarking that both molluscs and crustaceans made similar marks on the sand. But no gasteropods except minute species are known in these ancient rocks, and there is such a variety of trilobites both for size and form in the Acadian series to which Psammichnites extends that the trilobita do not seem likely to have given origin to a track so unchanging in size and with such features as this possesses.

Psammichnites is most probably the track of a gigantic marine worm. The centre is moderately depressed and there is the same tendency to make little ridges on each side of the track when passing over the raised part of ripple-marked sandstones and to throw casts (of the intestinal canal?) in the hollows or depressions between the ridges, which may be observed to characterize the operations of worms on the sea shore at the present day. The track however, differs from ordinary worm trails in its directness, running almost straight for many inches and sometimes for the distance of a foot, and deviating from the straight line only in long open curves. As it lacks the sinuousness of the ordinary worm track, the animal that made it may have had perceptive organs to guide it on its course, differing from those of ordinary worms.

The track is about three-quarters of an inch wide and is often marked by a groove or depression in the middle, as in Cruziana. Apparently the same track is found in the Acadian series near its base where the casts that accompany it occasionally contain shells of brachiopods (*Linnarsonia*) pteropods (*Diplotheca*) and tests of trilobites (*Agraulos, &c.*). Whether these are accidental enclosures, or have passed through the intestinal canal is not clear, but the latter view seems more probable. This fossil track serves to link the two series and shows with other biological features that the lower, as well as the upper series, is of Cambrian age.

The lower series also contains worm tracks of ordinary size (*Helminthites*) and the double worm burrows named by J. W. Salter *Arenicolites*. It has also yielded an example of a large thin-shelled brachiopod similar to *Lingula* (?) *monolifera* of the Eophyton sandstone of Sweden.

This series of Cambrian rocks is about 1200 feet thick.

B. Acadian series.

The series above described is overlaid unconformably by the Acadian or St. John series which has an abundant trilobite fauna in its lower part—Stage (or Division) 1. All the genera of trilobites of this stage are known in the Cambrian system in Europe, and are the following: Paradoxides, Ellipsocephalus, Solenopleura, Ptychoparia, Liostracus, Agraulos, Ctenocephalus, Conocoryphe, Microdiscus and Agnostus.

Trilobites in the comparative rapidity with which they were introduced in the several layers of the palæozoic strata, and the short period during which the species remained in existence, serve the same purpose in discriminating the members of the ancient geological systems, as in the Tertiary strata is fulfilled by the mammals. This peculiarity of these ancient crustaceans is well shown in the close parallelism of the species on both sides of the Atlantic, and the rapid exchange of one species for another in passing from older to younger beds of the Cambrian system. In the lower part of this system (*e. g.* stage 1) we do not find many identical species in Scandinavia and Acadia; but there are a large number of representative species; these do not occur in exactly the same order in the two countries, for some forms that show themselves first in Europe, as *Paradoxides tessini*, appear later here (*P. abenacus*); and others that are found among the oldest here *P. eteminicus* (*cf. P. rugulosus*) make their appearance as constituents of a later sub-fauna in Europe. There are some sub-genera of trilobites that are peculiar to this side of the Atlantic, but the genera are alike on both sides.

An apparent exception to this rule is *Paradoxides* (?) *kjerulfi* of Scandinavia, of the oldest trilobite layer in that country; but the apparent absence of such a form on this side of the sea is probably due to the scarcity of organic remains in the corresponding beds in Acadia.

TABLE SHOWING THE RELATIONSHIP OF THE TRILOBITES OF STAGE I OF THE ACADIAN SERIES, AND THE HORIZONS AT WHICH THE SPECIES ARE FOUND.

GROUP.		GENUS.		b	c		d
TRILOBITA: 1. Eyeless, short thorax,	Agnostus	regii			*regulus.*		
		fallaces				*vir*	var. *concinnus.*
						acadicus	var. *declivis.*
		longifrontes				*partitus*	*acutilobus.*
							obtusilobus.
						sp. cf. *fissus*	sp. cf. *nathorsti.*
		parvifrontes					*tessella.*
							umbro.
		Microdiscus			*dawsoni.*		
						precursor	*pulchellus.*
2. Eyeless, long thorax,	CONOCORYPHINÆ	Conocoryphe			*baileyi* var.	*baileyi* and var.	
					walcotti	*elegans.*	
		Ctenocephalus			*matthewi* var.	*matthewi.*	?
3.	Ptychoparidæ	Agraulos		*articephalus.*	*whitfieldianus.*	sp. cf. *ceticephalus.*	
						hallianus.	
	Ptychoparidæ: PTYCHOPARINÆ	Liostracus			*tener.*		
					ouangond var.	*ouangondianus.*	
		Ptychoparia					*linnarsonia* and var.
		Solenopleura			*robbii* vars.	*robbii* & var. *orestes*	
							acadica and var.
	Ellipsocephalidæ	Ellipsocephalus		sp. cf. *polytomus.*			
4. Paradoxidæ	Paradoxides	test granulated				*acadicus* and var.	
		test wrinkled			*eteminicus*	*eteminicus.*	
					micmac.	*micmac.*	
						pontificalis.	
		test granulated			*lamellatus.*		
		hypostomæ without spines					*abenacus.*
						regina.	

The foregoing table shows the species found in Stage 1 of the Acadian series. No organic remains are known from Band (or Assise) *a*, and it is therefore omitted from the table; and to exhibit better the relations of the rich fauna of *c* the column containing it is divided.

In this table the genera are arranged according to their apparent relationship to each other. In Group 1, are placed the species devoid of eyes and having a thorax of a few joints only. Group 2, includes the genera with longer thoraces, but which like the first group have no visible eyes. Group 3 contains the smaller species which possess eyes, and group 4 the large species, *i. e.* the Paradoxides.

The trilobites of Group 1, for various reasons are to be regarded as the most primitive of the genera of this fauna. They have no visible eyes, the joints of the thorax are few, as in the first larval stages of all trilobites; and the cephalic and caudal shields show little change in aspect from the youngest known to the adult stage. Of the two sections into which this group is divided we cannot hesitate to give to the Agnosti the first place for simplicity of structure, and for the most perfect retention of embryonic features. Among these are the long narrow glabella possessed by the most abundant of the early Agnosti, and the clubshaped glabella of another of the earliest types. The Agnosti are also primitive in the absence of movable cheeks and the want of genal spines, but more especially in having pleural joints barely sufficient in number to enable the animal to fold itself together.

This genus is highly characteristic of the Paradoxides beds both in Europe and America. S. A. Tullberg divided the Agnosti into four sections, three of which are represented in the beds of Stage 1, of the Acadian series, and they appear here in much the same chronological order as in Europe.

This primitive genus is worthy of special study. In its peculiar thorax, the joints of which are simply hinged together, without free ends arranged for sliding one over the other, it differs from all its cotemporaries. Although the writer in this paper has grouped it for convenience with Microdiscus, the feature last named as well as the unchanging aspect of the shields in young and old examples of Agnostus separate it very

decidedly from the preceding genus, and show that the two cannot be considered as belonging to one family. Tullberg's division of the Agnosti into four sections is eminently convenient and useful; both as showing the natural relations of the species, and also for determining the position and relations of new species. It may not be a perfectly natural one, as there is at least one species at Saint John which by its furrowed and punctate checks and thin test is related to the *Longifrontes*, but does not possess a furrow dividing the cheeks in front of the glabella; it therefore is not a Longifrons according to Tullberg's definition. So also the sections of the *Limbati*, which Tullberg designates respectively "Regii" and "Fallaces," in the light of the development of the trilobites from their earlier stages seem worthy of more prominent place than Tullberg has given them; in the above table the species that belong to these sections are shown, as well as those that fall into the "Longifrontes" and "Parvifrontes."

Microdiscus though first named by Dr. Emmons is properly based on the species (*M. punctatus*) described by J. W. Salter from the Welsh Cambrian measures; this species was found to have four joints in the thorax, but Mr. S. W. Ford has since found that a species of the Georgian fauna (*M. speciosus*) has three joints; this number again is further reduced by the discovery of the thorax of *M. Dawsoni* which proves to have only two joints; at least this was the number found in an example three quarters grown. A thorax with 2-4 joints should therefore be ascribed to Microdiscus.

Microdiscus shows an advance of development above Agnostus in many respects, and cannot be regarded as of the same family. The pleuræ are built to give facility for sliding one over the other at their extremities, and the pygidium has the power of increasing the number of the rings of its rhachis. This feature is best seen in the latest of the three forms of the species noticed in the above table which when one quarter grown posseses seven rings. This is the number in the adult of the earlier species *M. Dawsoni* and also according to Mr. Salter marks *M. punctatus* the type of the genus, to which *M. pulchellus* is closely allied, but at maturity our species has ten or eleven rings in the rhachis of the pygidium. Three rings is the normal

number in the rhachis of Agnostus. Each of these rings has an individual character, and we cannot doubt indicated features in the economy of this genus different from Microdiscus or any other trilobite of the fauna in which Agnostus is so characteristic an element.

In Group 2 (the Conocoryphinæ) are trilobites in which one cannot fail to see a great advance in development beyond those above described. Here a facial suture is introduced, and protective spines at the genal angles. The thorax shows greater mobility in its parts and receives joint after joint at the distal end until a long body is built up, capable of folding upon itself beneath the head shield and within the protection of the genal spines.

Besides the provision for extending the length of the thorax, the head shield in this group of trilobites undergoes a great change of form during its growth. The change of form in the proportion of the parts of the head shield and the continuously growing thorax indicate the appearance of powers of metamorphosis in this group not possessed by the two genera above described, and ally the Conocoryphinæ to the succeeding groups.

The trilobites of Group 3, include genera which by their persistence in time have become characteristic of the Cambrian system as a whole, and in this the group differs from the preceding one, which is eminently characteristic of the Lower Paradoxides beds. As the trilobites of Group 3 extended so far onward in time, so were they the first (so far as our knowledge goes) to invade the shallow bays in which the earlier beds of the Acadian series were deposited. But the pioneer species of this group by their compact forms and thick test, seem to have been specially adapted to live in the shallow margin of the Cambrian sea, and so are the first trilobites observable in the barren sandstones of Band *b*. But they are not for this reason more ancient than the simpler forms of Group 1, which preferring deeper water and a muddy bottom may have existed simultaneously in the neighboring ocean.

By a comparison of the embryonic and larval forms of the trilobites of Group 3, the close family connection of the genera forming it is manifest. The development of the young in this

family (Ptychoparidæ) is perhaps more instructive than in any of the others, as in its earlier stages the young Ptychoparian passed through a metamorphosis which reminds one of the adult trilobites of Group, 1, especially the Agnosti; and later, in the early larval stages, recalls the more primitive adult forms of its own group.

The embryonic forms of these trilobites are distinguished from the larval by the approximation of the posterior glabellar furrows to each other and to the occipital furrow, as well as by the narrowness of the occipital ring; the anterior of the three glabellar furrows is also very distinct at this period and distant from the others; and the whole glabellar ridge is narrow behind this furrow, but enlarged in front. All these features are to be found in the *Limbati* among the Agnosti, in their adult condition. The Ptychoparinæ in their embryonic stages possess few or no thoracic joint, and are typified by the Agnosti in their adult condition.

Of the Ptychoparians the genus Agraulos presents the most simple form of head shield. The dorsal suture is more direct and nearer the margin of the head shield than in the others and the surface of the shield is more even, descending all around to the margin. These features can be seen to be presented with more or less distinctness in the early larval stages of the other Ptychoparians, whether the individual in its later stages develops into a Liostracus, a Ptychoparia, or a Solenopleura.

Passing to the next group (Group 4) we meet with species which by their great size attracted notice at a very early period, and are regarded by all palæontologists as peculiarly characteristic of the lower part of the Cambrian system. The Paradoxides differ not only in their adult condition, but also in their stages of development from the other trilobites of this series (the Acadian). But though in their structural modification and their development they differ from most of the others, they retained throughout life the general outline of the embryonic form of the glabella; only in the Regii among the Agnosti and in Ctenocephalus among the Conocoryphinæ, and less perfectly in Ellipsocephalus of Group 3, do we see the remains of the enlarged anterior end of the glabellar ridge of the embryo; but in all the Paradoxides this feature is very distinctly preserved.

The last named genus exceeds all the others in the development of the thorax, both in the number of the joints and in the mobility of the segments. And corresponding to this is the great development of the movable cheeks and genal spines.

The Paradoxides of the Acadian series are remarkable for the large number of species with continuous eyelobes; this feature is more marked in the early larval forms than at later stages in the life of the trilobite, and is an embryonic character which is more prevalent among the species which first appeared than in those which existed in the closing period of the reign of the Paradoxides. The eyelobe in the early stages of growth in this genus was separated from the anterior margin by a broad flat area, which in later stages was considerably narrowed at the front. But in the Ptychoparinæ the relative changes in these parts were quite the reverse of this; for counting the ocular fillet in this sub-family as analogous to the front of the palpebral lobe in Paradoxides, the space between it and the anterior margin became continually wider as the trilobite grew.

The following are the species which in Europe most nearly represent the Acadian forms of this genus:

European.	*Acadian.*
Paradoxides sjogreni. P. ——— harknessi?	Paradoxides acadicus.
P. ——— olandicus. P. ——— rugulosus. P. ——— palpebrosus.	P. ——— lamellatus. P. ——— eteminicus. P. ——— micmac.
P. ——— brachyrachis. P. ——— hicksii?	P. ——— pontificalis.
P. ——— forchammeri? P. ——— spinosus?	P. ——— regina.
P. ——— tessini.	P. ——— abenacus.

There are many points of interest relating to the early life of the Cambrian age that have not been touched upon in the above remarks, but to detail them here would swell this paper to unnecessary proportions. Sufficient has been said to show how replete with interest to the biologist is the threshold of palæozoic life and how nearly the development of the early Cambrian faunas corresponded on the two sides of the Atlantic.

PALÆONTOLOGIC AND STRATIGRAPHIC "PRINCIPLES" OF THE ADVERSARIES OF THE TACONIC.

BY JULES MARCOU.

The publication by Mr. Charles D. Walcott of his opinions, views and "principles," in order to have the question of the Taconic system "intelligently understood and decided," is a proper occasion to show the way in which the adversaries of the Taconic have constantly made use of and are still making use of palæontology, stratigraphy and lithology.

The paper of Mr. Walcott is entitled, "The Taconic system of Emmons, and the use of the name Taconic in geologic nomenclature," with a plate containing, "geologic map of portions of eastern New York, western Vermont, western Massachusetts, and northwestern Connecticut, compiled under the supervision of Chas. D. Walcott;" and a section crossing the original Taconic area in Washington Co., N. Y., from Northumberland, the Hudson river, Fort Edward, south of Argile and Salem, and cutting through Bennington Co., Vermont. (Amer. Journ. Sci., vol. xxxv, March, April and May, 1888, pp. 229, 307 and 394, New Haven.)

PALÆONTOLOGY.

TRILOBITES. Dr. E. Emmons described in 1844 *Atops trilineatus*, a new genus and new species of trilolites. "Mr. James Hall insisted upon the identity of the *Atops* and *Triarthrus;* notwithstanding the decision years ago by a committee of the American Association of whom (sic) Conrad was a member, was against Hall."[1] Suppressing the genus and the species, Mr. Hall has identified that primordial trilobite with the *Calymene* (*Triarthrus*) *beckii* of the Utica slate, a trilobite very abundant and characteristic of the upper part of the second fauna. Mr. Fitch in 1849 followed Mr. Hall's determination.

Barrande in 1861,[2] disputes Mr. Hall's determination and maintains Emmons' opinion; saying in regard to *Atops punc-*

[1] Letter from Emmons to J. Marcou (*Proceed. Amer. Acad. Arts and Sci.*, vol. xii, p. 188, Cambridge, 1885).

[2] "Documens sur la fauna primordiale et le Taconique, etc." (*Bulletin soc. geol., France*, vol. xviii, pp. 269, 270 and 271, Paris.)

tatus, a variety of *A. trilineatus;* "it is impossible for us to unite *Atops punctatus* with *Triarthrus beckii*, either as the same species, or even the same genus." Marcou in 1860, regards *Atops trilineatus* as a true *Sao*, one of the most characteristic genera of the primordial fauna of Bohemia and Scandinavia.[1] Since then I have always maintained the primordial character of *Atops trilineatus* and opposed Mr. Hall's identification with *Calymene beckii* (The Taconic of Georgia, etc. *Mem. Boston Soc. Nat. Hist.*, vol. iv, p. 128, 4th, Boston, 1888.)

Mr. Walcott in 1879, many years after Barrande and Marcou's publications, maintained Mr. Hall's determination and placed *Atops trilineatus* in the upper part of the second fauna, as a *Triarthrus beckii*, in his paper, "Fossils of the Utica slate and metamorphoses of *Triarthrus beckii* (*Trans. Albany Inst.*, vol. x, June, 1879, p. 23, Albany). Retracting his opinion of 1879, Mr. Walcott in 1886, *Bulletin U. S. Geol. Sur. No. 30*, considers it as a *Ptychoparia trilineata* retaining only the specific name of Emmons, and placing the fossil in the primordial fauna, instead of the second fauna, showing how little he knew in 1879 of the stratigraphic position of Emmons' fossil. In 1887 Mr. Walcott changes a third time the genus of the fossil, calling it *Conocoryphe trilineata.* ("Fauna of the upper Taconic of Emmons, in Washington Co., N. Y." *Amer. Journ. Sci.*, vol. xxxiv, p. 137.)

Mr. S. W. Ford refers the same fossil first to the genus *Conocephalus*, 1871, then to *Conocephalites*, 1873, and finally in 1880 to *Conocoryphe;* all three genera being primordial; a fact which places him in a special catagory of the opponents to the Taconic.

We have here a remarkable example of false determination and wavering of the adversaries of the Taconic. After forty four years of opposition, they have not yet arrived at the determination of Emmons of 1844; but they have conceded first that the fossil is not identical with the very characteristic and common trilobite of the Utica slate *Triarthus beckii;* a fact received by Conard, Barrande and Marcou many years before they came to it; and second they have admitted the specific name of

1 "The primordial fauna, etc. * * * " (*Proceed. Boston Sci. Nat. Hist.*, vol. vii, p. 371, Boston.)

trilineatus after a disagreement between Messrs. Ford and Walcott, and finally they have accepted the genus as certainly primordial, wavering between four names and rejecting all the time Atops. It is for all impartial observers to say, whether it would not have been better for the progress of palæontology, to have adopted at once the determination of Dr. Emmons.

Elliptocephalus asaphoides, another Taconic fossil described by Emmons in 1844, is also a good species and a good genus, entirely primordial. Barrande in 1861, accepts the species, using the name *Paradoxides* for the genus, following Emmons, who in his *Manual of Geology*, 1860, p. 280, refers it to that genus. Mr. J. Hall calls it first an *Olenus*, then *Barrandia*, then *Olenellus*; besides he objects to *Elliptocephalus* on account of *Ellipsocephalus* of Zenker; and regards it as an *Ogygia* or *Olenus*, saying that "it evidently belongs to a Lower Silurian type;" he does not mean a primordial or a type special to the Taconic; no, on the contrary, he wants to take it out from the primordial, as that fauna was then [1847] known in Scandinavia and Bohemia. Mr. Hall regarded then and thirteen years after the "Olenus zone" of Hisinger and the primordial of Barrande, as placed, by those two *savants*, in a wrong stratigraphical position; and he tried to correct the European stratigraphy, which according to his view ought to have placed the primordial above the second fauna, instead of being below it.

If the name *Elliptocephalus asaphoides* of Emmons, and its geological position of pre-Potsdam had been accepted by the paleontologist of New York, we should have been spared the confusion created by three others generic names, and the placing of the *Olenus* zone above the Lorraine shales, that is to say, above the second fauna, a fact which astonished so much Angelin and Barrande.

Microdiscus—In 1855, Dr. Emmons, pursuing his studies of the Taconic notwithstanding the opposition made by its combined adversaries, described another new form of primordial trilobite, *Microdiscus quadricostatus*. Barrande in 1861, regards the specimen figured by Emmons and his very short description as too incomplete, and not well preserved enough "to judge with certainty the character of this trilobite." Since then Mr. J. W. Salter in 1864, from numerous specimens found in the

"Lingula flags" of Wales, has recognized Emmons' genus as good, with the single reservation that his fossil from Wales, *Microdicus punctatus* "may be the *fry of some larger* trilobite." (*Quart. Journ. Geol. Soc., London*, vol. xx, p. 237, 1864.)

Other species belonging to the same genus have been discovered since in America; first by Hart, and then after him Messrs. Walcott and Ford have described five species, in 1868, 1873, 76, 77, and 86.

As usual the adversaries of Dr. Emmons, seeming to be bound to reject all his discoveries, Mr. Walcott leaning upon the erroneous idea that "Emmons' original name * * * appears to have been founded on a specimen of the genus *Trinucleus*," is trying to change Emmons' name into *Pemphigaspis* Hall, given in 1863 to a small trilobite of Trempeleau, upper Mississippi valley. However Mr. Walcott has used the name *Microdiscus* in *Bulletin U. S. Geol. Sur.*, No. 30, p. 152, 1886; a concession very reluctantly and only momentarily granted.

Graptolites. The Graptolites have furnished the most constant weapon used to suppress the whole Taconic system. Mr. Walcott says: "In regard to the graptolites found near Hoosic, N. Y., I wish to state that I visited that locality and collected specimens of the flattened and distorted graptolites from the smooth shales. On comparing the specimens with those of *Diplograptus pristis* from the Hudson terrane (*sic*) at Fort Edward, N. Y., and also from the Hudson terrane (*sic*) in the western part of the township of Greenwich, Washington Co., N. Y., I fully concur with the opinion given by professor James Hall in 1857 ("Pal. N. Y., vol. 1, pp. 321, 322"—an error, it is pp. 265 to 268, J. M.—Pl. 72), that the Hoosick shale graptolite is identical with the *Diplograptus pristis* found in the Hudson terrane (*sic*), within the Hudson valley." (*Loc. cit.*, p. 240.) It is simply an endorsement, a great deal more easy to give than it was for Mr. Walcott to indorse the erroneous identification of Mr. Hall of the *Atops trilineatus* with the *Calymene beckii;* for a graptolite, to say the least, is always easily dealt with, being such a low form of animal. But without good figures and descriptions, the concurrence of opinion of Mr. Walcott with the one expressed by Mr. Hall, is valueless and can be classified with his concurrence of opinion for the

Atops trilineatus as identical with the *Calymene* (*Triarthrus*) *beckii.*

Dr. Emmons regarded the graptolites of Hoosic as different from any of those found in the Utica slate and Lorraine shale, and I fully concur with him and believe him; while on the contrary I distrust all that has been said on the subject by Messrs. J. Hall and Walcott. Mr. C. Lapworth, the English authority on the subject, and who has studied that very low and enigmatic fossil called *Graptolithina*, as a specialty, not only finds varieties from that species of *Diplograptus pristis*, which he identifies with the *Diplograptus foliaceus* of England, but even goes so far as to say that it "ranges up through at least *three complete zones*." At Covefields, near Quebec, Mr. Lapworth recognized three varieties of the true *D. pristis*, which he called, 1, *basilicus*, 2, *confertus*, 3, *platydens*. He identified the species, not the varieties, at several localities in the vicinity of Quebec. Besides he quotes four other graptolites as "species of long range." All this shows that the use of graptolites as characteristic fossils, is attended with a want of exactness, both in the determination of species and in their fixity in strata.

But this is not all; the use made of them by Mr. Walcott requires another citation and calls for a remark. He says: "Mr. C. E. Beecher found three of the same species of graptolites (*Clim. bicornis*, *Dicra. ramosus* and *Diplogr. mucronatus*) as those found by me in the "Taconic slates" of Washington and Rensselaer counties associated with brachiopoda five species; lamellibranchiata, sixteen species; pteropoda, two species; gasteropoda three species; cephalopoda, two species; annelida, one species; crustacea one species, and trilobites two species." [*l. c., foot-note*, p. 322.] Such a fine second fauna and even of the upper part of the second fauna, indicates absolutely that north of the Dudley observatory on the line of the New York Central railroad, we have the Utica slate. But it does not follow that the other locality at Kenwood near Albany where graptolites have long been known to exist, belongs to the same formation. For there no trace of the second fauna exists, except a single oboloid shell. A fauna so rich in *lamellibranchiata* and containing two trilobites, the *Triarthrus beckii* and *Trinucleus concentricus*, cannot be confined to a single point of the Hudson

valley, the Dudley observatory near Albany; and such a good fossil-hunter as Mr. Walcott ought to have found many localities in Washington and Rensselaer counties, or in Berkshire, Bennington, Rutland, Addison, Chittenden and Franklin counties, where he indicates with such certainty the existence of vast surfaces covered by the Hudson [Lorraine and Utica]. To be sure he has found there the *Triarthrus beckii*, as determined by Mr. J. Hall, and endorsed as exact by him in 1879; only he has come to the conclusion, in 1886, that the *Triarthrus* [*Calymene*] *beckii* of Washington county was not that species, not even that genus, and he has been obliged to refer it, not to *Atops trilineatus* of Emmons, but still to regard it as a primordial fossil.

The negative result of the researches of Mr. Walcott in the Taconic area for discovering the beautiful Utica fauna of Dudley observatory is of great importance. As such a fauna was never found in the slates and shales of Canada, identified by the adversaries of the Taconic, first with the Utica-Lorraine group, and afterward referred to the Quebec group, Dudley observatory is an exception, not in regard to the fauna, but only in regard to the three graptolites, on which I shall return further on, when I shall treat of the stratigraphy and lithology.

There is however one part of the graptolite question on which Mr. Walcott has neglected to instruct us; it is, whether those three graptolites [*C. bicornis*, *D. ramosus* and *D. mucronatus*] have been found ever in the Utica slate at Utica, or any other localities west of Albany and Dudley observatory, or in the typical localities of the Lorraine shales in Lewis and Jefferson counties, N. Y.

Fossils of the eastern quartzytes. For many years the eastern quartzytes of the Taconic area have been known to contain a few fossils. Messrs. Hall and Dana have determined a *Lingula*, related to a species in the Medina sandstone [upper Silurian], many casts of one valve of a so-called *Modiolopsis*, and an *Orthoceras*, indicating according to their views, more especially the Lamellibranchia, that "the eastern quartzyte formation is of the age of the later Trenton, or Cincinnati group." [*Amer. Journ. Sci.*, vol. xiv, p. 207, 1877.] Mr. Walcott does not refer in any way to the *Lingula*, except to say that "Prof. H. S. Seely had traced the Rockville *Lingula* to a boulder."

[*Loc. cit.* p. 235.] The "*Modiolopsis* like shell" instead of being a Lamellibranch, is referred by Mr. Walcott to a Crustacean, called *Nothozoe vermontana;* and the *Orthoceras* is fcr him a cast of *Hyolithes communis.* Besides Mr. Walcott has found the *Olenellus thompsoni*, which put an end to "the age of the later Trenton or the Cincinnati group," of Mr. Dana, for the eastern quartzyte formation. The state of anarchy created by Messrs. Hall, Dana and Walcott, in regard to the fossils and age of the eastern quartzyte has been increased, if possible, by Mr. Whitfield who has referred this eastern quartzyte to the "Potsdam sandstone." [*Bulletin Amer. Mus. Nat. Hist.*, vol. 1, p. 145, 1884, New York.]

FOSSILS OF THE STOCKBRIDGE AND SPARRY LIMESTONES.— In his paper Mr. Walcott avoids describing, discussing or even giving the names of the fossils found in the limestone, lenticnlar masses, or limestone belts (as he calls them) inclosed in Taconic slates; saying "I think it unnecessary to restate the evidence given by Prof. Dana to prove that this limestone belt is the representative of the Trenton-Chazy-Calciferous series of the western side of the Champlain basin" (*Loc. cit.* p. 237). However he gives the name and even the figures of a few fossils found in the town of Pownal, Vt., at Mount Anthony, at Graylock peak, at South Berlin and at Hoosic falls, nine species in all, without descriptions. All are only "closely allied" with Cincinnati or Trenton fossils, with the exception of *Solenopora compacta*, which is the only fossil identified. Mr. Walcott does not pay any attention to the sporadic character of the geological position of those fossils, nor to their associations, nor to their numbers, nor to their preservation, except that they are "weathered out in relief on the surface of a compact, clouded marble."

STRATIGRAPHY AND LITHOLOGY.

Dr. E. Emmons says: "The Taconic system as a whole, may be regarded lithologically as an immense slate system, with subordinate beds of sandstone and limestone. It rests unconformably upon primary schists and passes beneath the New York system." "The sandstones, limestones and slates are not only different in their relative position, but they are much thicker than those with which they have been supposed to be

identical in the New York system." *Agric, N. Y.*, vol 1. pp, 361 and 108. 1846. All that is true to the letter, and is as admirable an instance of observation and classification as is the paleontological discovery of the primordial fauna in America.

The adversaries of the Taconic series at first denied it in toto dismissing the question, by saying that the Potsdam was the oldest stratum lying on the primitive crystalline rocks, and that there were no strata below. For the Taconic of Dr. Emmons, it was only the lower Silurian or Champlain division, the upper Silurian, the Devonian and even the Carboniferous, each and all metamorphosed. For them the Hudson River group was most important, with a thickness of twenty thousand feet; and in it was the *Olenus* zone of Scandinavia described by Hisinger and Angelin, and the primordial zone of Bohemia of Barrande. Such was the creed promulgated by Mr. James Hall, and accepted and sustained by Messrs, Logan, Dana, the brothers Rogers, Mather, Hitchcock and their followers.

It was simply the suppression of a whole series, divided now into three systems (lower, middle and upper Taconic,) of a thickness of at least 25,000 feet, containing three great faunas, and the most important which is on earth, being the beginning of the animal kingdom (infra-primordial, primordial and supra-primordial).

We have here the two or three first applications of "principles," and certainly all of an extremely easy application for disposing of the most difficult and important part of the great time divisions of the sedimentary strata of North America. Those "principles" are simply; (1) suppression of 25,000 feet of strata; (2) identifications of primordial fossils with some of the upper part of the second fauna; (3) transposition of the primordial genera *Olenus* and *Atops* above the second fauna; and (4) explanation by metamorphism of all the strata existing in the Taconic area, referring them to the Lower and Upper Silurian, the Devonian, and the Carboniferous. Such are the "principles" made use of by adversaries of the Taconic system from 1842 to 1860.

Directly after the publication of the paper entitled: "On the primordial fauna and the Taconic system by Joachim Barrande, with additional notes by Jules Marcou," Boston, 24 Dec.

1860, a change was made under the pressure of that joint paper of Barrande and Marcou. At first the geological survey of Canada maintained its stratigraphic position unassailable, but after weighing carefully the contents of the paper, and the consequences which might follow, the Director, Logan, without going over the field at Georgia or at Points Lévis and Montmorency — a material impossibility for the ground was buried under four feet of snow since the first day of December and even before — wrote his printed letter to Barrande, dated 31 Dec. 1860, in which he admits "an overturn anticlinal fold with a crack and a great dislocation running along the smmmit." According to Logan that great fault, which he had failed to recognize in the field and in situ, during his eighteen years of explorations, finding it only in his office at Montreal, on New year's eve of 1861, as an expedient and an explanation to change his base of the stratigraphic scale of Canadian geology— "passes the boundary of Canada not over a couple of miles from lake Champlain" east of Phillipsburgh; then "it proceeds in a gently curving line to Quebec, keeping just north of the fortress; then it coasts to the north side of the island of Orleans;" "afterwards it keeps under the waters of the St. Lawrence to within eighty miles of the extremity of Gaspé, then again it leaves a strip of the Hudson River or Utica formation on the coast." "Remarks on the fauna of the Quebec group etc.," p. 4, Montreal, 3rd Jan., 1861." Such a find made in an office of a geologist is unique, and shows a curious result of the joint publication of Barrande and Marcou. Not satisfied with one great fault, Logan in May 1861, added a second great fault at Montmorency opposite his overlapping fault of the Island of Orleans, and strange to say his successor Mr. Selwyn added to the two faults of Logan, a third great fault on the southern side of the island of Orleans, and has the courage to trace "the approximate course of the great St. Lawrence and Champlain fault" unhappily almost all the time buried under water, and stopped short just in the middle of the gulf of St. Lawrence. [*Map of the Dominion of Canada*, geologically colored, 1842 to 1882.]

However Mr. Lapworth disagrees with both Logan and Selwyn, in regard to the existence of those great faults for the

last "eighty miles of the extremity of Gaspé," which he says "are destitute of any clear evidence that true Utica and Hudson River strata occur anywhere along the south side of the St. Lawrence from Gaspé to Quebec." [*Ch. Lapworth, On graptolites from Lower Palæoz. rocks*, 1886.] The finding of great faults where before "the most able stratigraphical geologist of the American continent," had found only a perfect concordance in the stratification, was not the only change in "the principles" of the adversaries of Dr. Emmons; Logan transported the "Olenus zone" from the top of the Lorraine shales, that is to say above the second fauna, to its base, and put it in the Potsdam as a subordinate part; and then created a new great division of strata which he called "Québec group," placed between the Potsdam and the Birdseye, Black River and Trenton, and as an equivalent of the Calciferous and Chazy divisions.

In 1861, during his first visit at Georgia, Marcou recognized that the "Olenus zone" is not a part of the Potsdam, but far below, in the middle of the Taconic. He referred also a part of Point Lévis formation to the Taconic.

In 1862, after two explorations at Quebec and in the northwestern part of Vermont, Marcou gave "comparative tabular sections of the upper Taconic [or true Taconic] rocks in Vermont and Lower Canada" in which he creates the Phillipsburgh and point Lévis group, and Swanton slates, or city of Quebec group, placing them between the Potsdam sandstone and the Georgia slates, as the upper part of the Taconic. He also calls attention to that great stratigraphical fact, unknown until then, of the existence at different levels of the Taconic, of lenticular masses of limestone, marble, sandstone, varying in size from a fist to masses several thousand feet in length, and a hundred feet thickness. After a stay of several months in 1873 and 74 at Higngate Springs, Vt., Marcou came to the conclusions that the sporadic second fauna fossils, found in some of the lenticular masses of limestone, are only colonies inclosed in the Phillipsburgh and Swanton groups; and that all the second fauna fossils found in the upper Taconic are only precursors of the second fauna inclosed in the supra-primordial fauna, where these are mixed, more or less according to localities, with primordial fossils, such as: *Olenellus*, *Dikelocephalus*, *Arionellus*, *Bathyurus*,

Menocephalus, *Conocephalites*, *Agnostus* and *Camerella*, *etc*. In his two papers: "*Sur les colonies dans les roches taconiques* etc., 1881," and "*The Taconic system and its position* etc—1885," Marcou gives his reasons and proofs for placing in the Taconic, all the sporadic species of the second fauna; identified as existing in the upper primordial; a very small number—a dozen at most—and he shows that such a mixture of forms and species of the second fauna, with forms of the first fauna exists and even on a greater scale, in Bavaria, Norway, Sweden and in Wales. These conclusions of Marcou, explain all the confusion and errors arrived at by the adversaries of the Taconic, in the original Taconic area. To be sure they differ also from Dr. Emmons views in a few minor points, where Dr. Emmons thought that he had found Calciferous, Chazy and Trenton layers of limestone, resting in discordance of stratification above the Taconic slate. A few words and quotations will show the difference and clear up the question, which has been such a stumbling block to all the observers.

Explanation of the fossiliferous limestone inclosed in the Taconic slates. Dr. Emmons found, inclosed in the great mass of slates of the Taconic system, limestones scattered almost all through the area, from the vicinity of Williamstown to Troy; and north and south of that line. He rightly classified in the Taconic system the Stockbridge and Sparry limestones; only owing to the special area where he studied them, [Berkshire, Columbia, Rensselaer, Bennington and Washington counties,] he finds them directly super-posed and in concordance of stratification on the granular quartz, and he thought that they succeeded them in the tabular classification and index of the Taconic strata. He was misled by a stratigraphical accident, which is not rare in great mountainous countries like the Alps, the Jura or the Pyrenees; or in any very distorted mass of old strata, as in Britanny and in the Cantabrian mountains of Spain. At the initial points of dislocation and upheaval, near the centre of the ranges, the main part of the lower strata are concealed [*se derobent*], being replaced by the upper part of the broken up and folded system of strata, lying in concordance of stratification on the base of the formation; the concordance being a result of folding, stretching and sliding.

The curvatures, folds and contortions to which the Taconic system was subjected accompanied by enormous lateral pressure explain the position of the Stockbridge and Sparry limestones in the area of the original Taconic. Farther north their positions are normal and at St. Albans, Highgate Springs, Phillipsburgh and all over eastern Canada, they lie no more on the quartzytes, but at their right places above the Georgia slates. However even in the Taconic area, parts of the Stockbridge and Sparry limestones are found in their right places above the Georgia slates, at Bald mountain, Whitehall, Shoreham, etc. Very likely special lithological structure—those limestones of the Phillipsburgh and Swanton groups assuming a thickness so great [3,000 feet and more] as to give them the form of a great mass or belt of marble as at Stockbridge, Rutland, Middleburg and Winooski—combined with the proximity of the two great and enormous pillars of crystalline rocks of the Adirondacks, Green and White mountains, which pressed on both sides the broken and upheaved Taconic series, created a special dynamical structure for the original Taconic area, which explains the error of Emmons.

The other mistake of Dr. Emmons is, regarding some lenticular masses of limestone, scattered in some places, as at Bald mountain, Whitehall, Cantonment hill, Snake mountain, as belonging to the limestone divisions of the Champlain system. He thought they were remnants left by denudation, scattered in discordance of stratification on the tops of hills formed at the base by the Taconic slates; or as colonel Jewett told me at Albany in 1861, bags of Champlain limestone deposed in a depression or hole in the Taconic slates. My discovery in 1861 and '62 of lenticular masses of limestone and sandstone inclosed, and of the same age as the Taconic slates, all over the Taconic system, gives for the first time a consistent and satisfactory explanation of all those isolated masses of supposed Champlain limestone. I was unable to communicate my discovery to Dr. Emmons, who had been shut up into the lines of the Confederacy for two years; but I did discuss the question with colonel Jewett, who agreed entirely with me, adding his own observations around Troy, where he saw some of those isolated masses of limestone quarried for a lime kiln, which had been entirely

dug out, and in them he had observed that the slates were wedged into the limestone, proving their contemporaneity of deposition.

The mistake of discordance of stratification spoken of by Emmons, is explained by the lithological and stratigraphical nature of the rocks; first the masses of limestone are generally badly stratified, being of an elliptical or ovoid form; and second the slates in which they are enclosed are all strongly cleaved, the cleavage being very different and entirely distinct from their plane of stratification.

But there is a point in the opinion of Dr. Emmons which is certainly correct; it is, his belief that the Taconic slates exist below and under those limestone masses; as it is given in his Whitehall section and in a part of his Bald mountain section. Being lenticular masses of limestone inclosed in the Taconic slates, they are of course surrounded entirely by slates, and all the bases of the hills and mountain on which they exist are composed of slates, which pass under the masses of limestone and reappear on the other side.

As customary, all the adversaries of the Taconic have opposed the observations and opinions of Marcou; and they have adhered to and adopted more or less the new "principles" suggested by Logan, in 1861. Some disagreement in regard to the Quebec group, the Potsdam, and the Hudson group, has been expressed at different times by some of them, but in the main they have agreed to continue the suppression, if not entirely of the Taconic system, at least of its name, using in place Potsdam and Quebec, and now Cambrian [not Sedgwick's Cambrian, but a Cambrian of their own].

The explorations of Mr. Walcott, in northwestern Vermont and in the area of the original Taconic, during 1883-84 and 1886-87, and his publications of the results obtained have changed the "principles" of the opponents; and we have now a third departure, different from the two others on many primary points, but agreeing in depriving Dr. Emmons of his discoveries, and American geological classification of its right of priority and of its just claims to occupy a place in the general geological nomenclature of the world. It is just to say that Mr. Walcott's opinions are far from the *ne varietur*, for he has changed al-

ready two or even three times several of his views always expressed as the result of "the accuracy of his original observations" during the very short space of three years.

(*To be continued.*)

ON SOME FOSSILS FROM THE LOWER COAL MEASURES AT DES MOINES, IOWA.

BY CHARLES R. KEYES.

The fauna of the lower Coal Measures as recently discovered in the vicinity of Des Moines has proved to be of considerable interest; of interest on account of (1) the profusion of minute molluscan forms, (2) the occurrence of species not hitherto reported from the state, and (3) the close similarity in many respects of this and the fauna of the lower Coal Measures of eastern Illinois, particularly that of the superimposing black shales of the "Danville" coal, or coal "No. 7" of the general Illinois section. Stratigraphically the relations of these two fossiliferous shales to the principal coal beds are the same—each forming the roof of the most extensive coal stratum in their respective localities; lithologically, the two shales are apparently identical. Hitherto, with a very few exceptions only fragmentary fossil remains have been obtained from the Carboniferous strata of the region around Des Moines; and for the most part the collections from this locality have consequently been very meager. The discovery then of a fauna embracing, as hereafter enumerated, thirty-six genera and nearly sixty species, the majority of them in a most perfect state of preservation, is, in its bearing upon certain phases of Carboniferous life, of especial significance. Though economically of far greater importance than any other formation in the state, the lower Coal Measures have received comparatively little geologic attention; and the two attempts at an exhaustive and detailed survey of this formation in Iowa, and a correlation of the different Coal horizons were, unfortunately, rendered abortive by circumstances entirely beyond the control of those engaged in the study of the Des Moines valley region. In Iowa the lower Coal Measures probably have a max-

imum thickness of more than two hundred feet; but notwithstanding the fact that at Des Moines the entire formation underlies the city, which is situated just at the eastern border of the middle Coal Measures this maximum is perhaps nowhere in Polk county attained. The base of the middle Coal Measures as characterized by St. John,[1] and as is well shown in several localities in the immediate vicinity of Des Moines, is composed of variegated clays and shales, with one or two intercalated bands of impure nodular limestone. These variegated shales have a thickness, at Des Moines, of thirty or more feet, and are easily recognizable at numerous exposures in the bluffs of the vicinity by the thin bands of limestone which, within the city limits, have yielded twenty or more species of fossils. Although the Des Moines and Raccoon rivers have in Polk county corroded their channels through the upper strata, the lower Coal Measures are fully represented from the underlying St. Louis limestone[2]—the nearest exposure of which is about thirty miles below Des Moines—to the superimposing variegated shales just mentioned. This formation, as represented in this vicinity, is composed almost entirely of clays and shales, with a few thin layers of soft sandstone and at least three workable beds of coal. The relative positions of the latter are shown in the following section at the Giant coal mine where the fossil forms hereafter noticed were chiefly collected:

Drift clay and carbonaceous shales	56 feet
Coal (No. 1.)	4 "
Shales, etc	20 ft. 6 inches
Coal (No. 2.)	4 " 6 "
Shales, lower layers fossiliferous	35 feet
Coal (No. 3.)	4 ft. 6 in. to 6 feet

The Coal Measures of Iowa have a general dip to the southwestward. To the northeast from Des Moines, the coal appears to thin out and finally is wanting altogether, as shown in the accompanying sections; the first at Altoona, nine miles from Des Moines; and the second three miles north of Mitchellville, or sixteen miles from Des Moines.

Drift and Carboniferous clays	110 feet
Shales	60 "
Sand stone	15 "

[1] White's Geology of Iowa, vol. i, p. 272.

[2] *Vide* White on the "Unconformability of the Coal Measures upon the older rocks," etc. Geology of Iowa, vol. i, p. 225, et seq.

Coal	1½ feet.
Shale	18 "
Coal	4 "

A boring near Mitchellville at the eastern border of the county shows an almost entire absence of coal; a statement of the material passed through is also given, though in a different form, in the second biennial report of the state mine inspector.

	feet.	inches.
Drift	64	
Blue and black shales,	17	6
Impure coal	1	2
Gray, black, blue and sandy shales with two layers of sandstone	141	7
Limestone with marly partings	89	6

Coals No. 2, and especially No. 3, are the most profitably worked, and furnish nearly all the coal mined in the county. Immediately overlying and thus forming the roof of coal No. 3, is a soft black clayey shale, sometimes slaty in places, highly fossiliferous and containing much iron pyrites in the form of crystals and nodules; many cubes of the former being over an inch along the edges, and the latter often containing shells of mollusca. The shell substance of the fossils from these shales, aside from those contained in the pyritiferous nodules, is replaced more or less completely by pyrite. In some specimens the replacement is complete, in others only a thin film of pyrite covers the shell leaving the interior of the shell substance with the original calcareous constituents; between the two extremes all degrees of replacement by pyrite occur. In a few instances —*Lophophyllum*, fish-teeth, and remains of crinoids—no replacement has taken place. The following tabular synopsis of the fossils thus far discovered and identified will illustrate the more important faunal features of the shales under consideration:

Fossils collected at Des Moines.

(The figures in parenthesis refer respectively to the number of genera and species in each group).

COELENTERATA. (2-2).

Lophophyllum proliferum McC.
Rhombopora lepidodendroides Meek.

ECHINO DERMATA. (1-1).

Eupachycrinus (sp?)

VERMES. (10-15).

Bryozoa. (1-1).

Synocladia biserialis, Swallow.

Brachiopoda. (9-14).

Lingula umbonata Cox.
Discina nitida, Phillips.
Productus nanus Meek and Worthen.
——— cora d'Orb.
——— muricatus N and P.
Chonetes mesoloba N and P.
——— (nov. sp.)
Streptorhynchus crenistria Phillips.
Spirifera camerata Morton.
——— lineata Martin
——— rockymontanus Marcou.
Spiriferina kentuckensis Shumard.
Athyris subtilita Hall.
Retzia mormoni Marcou.

MOLLUSCA. (20-34).

Lamellibranchiata. (7-9).

Myalina swallovi McC.
Aviculopecten cotanus M. and W.
——— neglectus Geinitz.
Nuculana bellistriata Stevens.
Nucula parva McC.
——— ventricosa Hall.
Schizodus (sp. und.)
Clinosphitha radiata Hall.
Solenomya soleniformis Cox.

Gasteropoda. (10-20).

Dentalium annulostriatum M. and W.
——— meekanum Gein.
Actæonia minuta Stevens.
Orthonema conica M. and W.
Streptacis whitfieldi Meek.
Aclisina minuta Stevens.
——— robusta Stevens.
Macrocheilus newberryi Stevens.
——— gracilus Cox.
——— (nov. sp.)
Pleurotomaria brazoensis Shumard.
Pleurotomaria graysvillensis N. and P.
——— carbonaria N and P.
——— (nov. sp.)
Anomphalus rotulus M and W.
Euomphalus rugosus Hall.
——— pernodosus M and W.
Bellerophon carbonarius Cox.
——— monfortianus N. and P.
——— percarinatus Conrad.

Cephalopoda. (2-5).

Orthoceras rushensis McC.
——— (sp. und).
Nautilus occidentalis Swallow.
——— lasallensis M and W.
——— winslovi M and W.

CRUSTACEA. (2-2).

Cythere nebracensis (?) Geinitz
Phyllipsia (sp. und.).

VERTEBRATA (2-2)

Pisces.

Petrodus occidentalis?
Diplodus (sp?).

Summing up the predominant faunal features as presented in the accompanying synoptical table, it appears (1) that in those groups having an optimum habitat marine there was not only a fewness of species but also an extreme paucity of individuals; (2) that brachiopods, though well represented in both genera and species, were not as proportionately abundant as might be expected when it is remembered that this type of life had now reached its culmination and greatest expansion, and (3) that the fauna was predominantly molluscan.

The cœlenterates, bryozoans, and echinoderms form indeed a very inconspicuous proportion of this local fauna, only three or four specifically distinguishable traces of each group being obtained. Though the brachiopods are represented by fourteen species included in nine genera they are with three exceptions of comparatively rare occurrence; *Productus muricatus*, *Chonetes mesoloba* and *Discina nitida* only being abundant. The brachiopods are, however, all depauperate, attesting conditions, at the time they lived, extremely unfavorable to their full development, and to the attainment of a normal size that under more congenial circumstances would have been rendered possible. Molluscan life, while the black shales forming the roof of coal No. 3 were being laid down, flourished luxuriantly, especially the gasteropods which in number of species comprise more than one-third of the entire fauna. Not only did the gasteropods exceed in species but they far out-numbered all others in individuals, while as a rule they were small in size, and some

of them even minute, their great numbers made up, in great part at least, for the conspicuity of larger but fewer forms. Though the majority of the forms of this group are small it is not a depauperation as among the brachiopoda, as is shown by the individual size of each species being normal and in some instances even considerably above. Some of these species are also of interest because of their recognition for the first time within the limits of Iowa and hence to a considerable extent their previously known geographical range is increased. Other of the species enumerated are already known to have a wide geographical distribution which is suggestive of a somewhat extended vertical range. Among recent mollusca and especially land forms, a wide geographical distribution, as has been referred to by Binney, appears to be indicative of a high antiquity for the group, and the corroborative evidence is abundant. A notable instance is the living *Zonites*, four or more species of which are circumpolar in their distribution, and this genus, even a subgenus (*Conulus*) to which belongs one of these living forms ranges back to the Carboniferous; while the modern genus *Pupa* is represented in the Carboniferous by four species. Cephalopods are not abundant in the shales under consideration, and are represented by only two genera and five species: yet one of the species of *Nautilus* attained a diameter of 18 cm. or 20 cm. and an *Orthoceras* reached a length of 50 cm. with a diameter at the larger end of 5 cm. Of the lamellibranchs the majority are small species; but two are comparatively large, attaining a length of nearly 10 cm. and having extremely thin shells. One specimen is of special significance as exhibiting in all the details the internal features of the shell, the characteristic, well defined muscular scars, and the edentulous hinge margin; in fact so closely does it resemble in these characters, and general form and external appearance, a modern *Anodonta* that it is difficult to see how it can be generically separated from it; and should further investigation prove that the specimens under consideration really belong to that genus it would be of unusual interest. The modern *Unio*, *Anodonta* and allied genera certainly have a wide geographical and geological distribution, as is shown by the rich discoveries of Unionidæ in the mesozoic and later strata of the west. The genus *Anodonta* is, if the opinion of Hall is

adhered to, represented even in the Devonian by two species, but that these two species really belong to *Anodonta* is by some questioned. Dawson has described several allied forms from the Carboniferous of Nova Scotia; their family position however is as yet also unsettled. With these considerations in mind the bearing of the evidence thus far obtained is towards a high antiquity for this interesting group of bivalve mollusks, which now is so abundantly represented in all our ponds and streams. Crustaceans are represented, as is shown in the list, by two species; a *Cythere*, and a trilobite of which only a single pygidium has thus far been found. Vetebrates are also rare—a few fin spines, about 2 cm. in length, and several dermal tubercles, and teeth.

ON SOME INVESTIGATIONS REGARDING THE CONDITION OF THE INTERIOR OF THE EARTH.

II

BY PROF. E. W. CLAYPOLE, AKRON, O.

Considering mathematically these evident inferences and treating them according to the law formulated by Prof. Darwin, Mr. Davison, of King Edward's School, Birmingham, England, has recently read before the Royal Society a paper in which he shows that in consequence of this law of contraction there must be a couche at some depth where the tangential compression occurring at the surface and due to the rigidity of a crust incapable of further contraction, must cease, and extension or as he calls it "stretching" must take its place. This result will as he shows occur whenever the horizontal contraction of a shell from cooling equals the diminution of space due to the total descent of all the shells below it from the same cause. A layer in that condition will descend as a whole and assume its new level without suffering either the lateral compression to which the couches above it are subject, (their contraction being less than their loss of room by descent,) or the extension to which those below it are subject, (their contraction exceeding their loss of room by falling into a sphere of shorter radius.) This shell

Mr. Davison calls the "layer of no strain." He shows that it sinks deeper with time. At the present day he places it at the depth of about five miles. It forms a limit between the bending and crushed layers above it and the squeezed and flattened layers below it.

If we understand Mr. Davison aright his conclusions are—first that above this level of "no strain" all the couches up to the surface are in a state of compression in consequence of their constant sinking, without equivalent contraction, to lower and lower levels, or to the surfaces of spheres of less and less radius. And secondly that below this plane of no strain the couches are in a state of extension—that is are being squeezed out because they are descending into a smaller space while their contraction exceeds this narrowing and would leave chinks or gaps were it not for the immense weight above them under which they are plastic and which squeezes them out laterally so as to fill these chinks or rather to prevent their formation.[1] The total vertical descent thus obtained of the upper surface of these extended couches exactly equals that through which the layer of "no strain" is ready to descend without extension or compression by its own contraction from loss of heat; while its horizontal linear contraction exactly equals the difference between its own circumference and that of the shell into whose place it is on the point of descending. Its continuity is therefore preserved.

It is obvious that the result obtained must depend on two primary data—the temperature of the surface at the time of consolidation and the time that has since elapsed. The higher the temperature of consolidation the longer must the cooling have continued to obtain the present temperature of the crust, while the same result would be reached by assuming a lower original temperature and combining it with a shorter period of cooling.

Mr. Davison assumes, following, he says, Sir W. Thompson, about 175,000,000 years as the time that has elapsed since the consolidation of the surface. On this datum he tells us that the cooling by radiation ceases, that is becomes infinitesimally small

[1] It is possible that in the highest portion of this sphere such chinks or crevices may be actually formed, but it is scarcely likely when we consider the enormous pressure, which is capable of crushing any known rock.

and may be neglected, at the depth of about 400 miles. From this level it increases upward to a maximum which he places at a depth of seventy-two miles and then diminishes again to an imperceptible amount at the surface.

Of course the couche of greatest contraction closely accompanies that of greatest cooling—if indeed the two are not identical—and this accordingly is found by Mr. Davison at about the same depth—72 miles, the contraction diminishing as the cooling, both upward and downward.

Pursuing his investigations Mr. Davison shows, as Mr. T. M. Reade had shown a few months previously, that between this layer of greatest contraction, where the space exceeds the matter, and the surface, where the matter exceeds the space (the latter being zero), must lie the layer of "no strain" and this he places, as said above, at the depth of about five miles. Below this the contraction from cooling exceeds the diminution of space by descent and the layers are consequently squeezed out or flattened to fill the vacancy. Above this the strata are crumpled or crushed because they are too large for the smaller space into which they are sinking.

The Rev. O. Fisher of Cambridge, England, in a review of the papers above quoted obtains results which differ considerably from those above given. Assuming the temperature of solidificacion at 7000 degrees F., he finds the depth of the shell of greatest cooling and contraction at fifty-four miles, and that of the level of "no strain" at two miles; while assuming an initial temperature of 4000 degrees F., the former would lie at a depth of thirty-one miles and the latter at a depth of 0.7 of a mile. These discordant results show us that geology is not yet in a state to speak with confidence upon the exact condition of the interior of the earth at given but inaccessible depths. In the former case the result would be attained in ninety-eight millions and in the latter in thirty-three millions of years.

Mr. Davison also remarks on the indisputable fact that in a cooling globe this layer of "no strain" which was once at the surface is constantly descending with time and he states that "within certain limits its depth increases with the square root of the time;" whereas according to Mr. Fisher's calculation it varies as the time. Its descent in the latter case must be much more rapid than in the former.

We will defer consideration of one or two of Mr. Davison's data for the present, in order to regard from a geological standpoint the already quoted statements of the mathematician.

While no doubt can exist concerning the reality of this layer of "no strain", within the crust of the earth, yet a careful consideration of the whole subject and of the inferences deducible therefrom, suggests to the physical geologist some reasons for thinking that in determining its position the mathematician has placed it too near the surface.

We take Mr. Davison's meaning to be that it lies at a depth of five miles beneath the solid crust of the sphere, disregarding the waters of the ocean, and that it therefore roughly follows the inequalities of the surface. This is indeed obvious, for the ice-cold water that fills the abysses of the ocean must by conduction and convection chill the crust below it at least as much as the continental areas are cooled by radiation. This seems to be confirmed by the fact that the beds of the great oceans are denser than the continents. We may therefore conclude that the layer of "no strain" not only rudely follows but somewhat exaggerates the contour of the surface, and lies at a less depth beneath the dry land than beneath the deep sea. If then it lie at the average depth of five miles it must under the continents lie at somewhat less than that depth.

Further, from the very nature of the case it was in the past during the palæozoic ages for example, nearer the surface than it is now. Yet again from its own nature—being a shell of perfect freedom from all stress and strain and consequently from all motion except the gentle subsidence caused by the contraction of the shells below it—it can never be elevated into anticlines or depressed into synclines.

Notwithstanding this inference we have in Pennsylvania strata now exposed, which at the close of the palæozoic era were buried, not only five, but even eight miles deep. The Trenton limestone, for example, was covered in some places with from 25,000 to 35,000 feet of newer strata. Yet it was subjected to compression and contortion and has been thrust up from that immense depth into huge arches and troughs. And there is little reason to doubt that beds lower still were included in those movements that produced the Appalachian revolution and closed the palæozoic era in North America.

Similar facts may be cited from English geology where the Lower Silurian and Cambrian rocks have been forced up from depths almost as great as those given above. The Huronian series of North America affords another case in point. Some of these have been brought to the surface from a depth greatly exceeding that which Mr. Davison assigns to the layer of "no strain."

A second point suggests itself as worthy of consideration, not as a necessary objection to the theory as a whole but as another fact requiring either a change in the depth assigned to the neutral layer or some corresponding modification in another department of geology, before Mr. Davison's conclusions can be accepted. The layer of "no strain" must be from its very nature, as already remarked, a perfectly quiescent shell in which no movement can possibly occur except the gentle secular settlement incident to its condition. No compression and no extension being the law of its existence it must form the only undisturbed shell in the outer portion of the terrestrial sphere. Above it the strata are subject to crushing and below it to squeezing. Being without movement it is of course quite impossible to find in it the seat of any of those disturbances that manifest themselves at the surface. Moreover the shell below it exists under such conditions that all movement in it must so far as we can see be very gradual and gentle. The temperature of its highest layer being about 500° F. and increasing downward and its mass, at least in the upper part, being more or less saturated with water, it must be for the most part in a state of aqueo-igneous or even of igneous plasticity. In such a mass under so constant and enormous a pressure no sudden or violent motion can take place. Any slight change in the intensity of the pressure will be met and corrected by gentle movement or "flow" of the plastic mass. It seems consequently hopeless to seek here any centre of disturbance or commotion. We are therfore driven by exclusion to place all such foci in the upper or compressed layer. That is in other words, we must seek the seat of the earthquake and of the volcano within five miles of the surface, in the layer where by hypothesis the strata are too cool to suffer much further compression by cold and are consequently bent and crushed as they

sink to a smaller spherical surface by the contraction of the hotter sphere beneath them. Here and here alone according to the theory now under consideration, among these yielding and breaking strata, can we seek with any hope of success the focus of the earthquake that spreads destruction and ruin at the surface, and of those volcanic vents which from time to time pour forth their streams of lava. This doctrine has long been familiar to seismologists. Here they have been accustomed to place the cause of the sudden jar that produces the one and the changing conditions of pressure to which in the present state of our knowledge we attribute the other.

But it will cause them not a little difficulty to learn that they must descend no deeper than five miles for this purpose. They will feel a serious objection to being told by the mathematician that they must limit their seismic investigations to so thin a layer of the crust. Possibly to this they must come at last but much readjustment will be necessary for the purpose. Few vulcanologists have yet placed their foci so near the surface. The late Mr. Mallet inferred from his observations that the shock of the great Neapolitan earthquake of 1857 radiated from a centre at the depth of seven miles, and the calculations of Capt. Dutton and other geologists of the U. S. survey have led them to place the seismic focus of the late Charleston earthquake at the depth of twelve miles. Probably neither Mr. Mallet nor Capt. Dutton would urge these results as anything more than approximations. But they and physical geologists generally will scarcely be willing to abandon their calculations without stronger evidence. The difference caused in the phenomena of an earthquake by the transfer of its focus from a depth of twelve miles to one of only five miles from the surface would be so great that it could not well be altogether due to errors either of observation or of calculation.

One other remark of Mr. Davison's deserves a moment's notice in passing. He makes the statement that "owing to the continental wrinkles the amount of stretching under them must have been very much less than under the great oceanic areas." But it is not easy to see how this can be the case. It seems an unavoidable inference from the nature of the layer of "no strain" that below it there can be no violent disturbance and that the

motion there, though very great, must be gentle rather than sudden, and must also be equally distributed. If moreover this layer be nearer the surface beneath the continents than beneath the oceans then a less thickness of the crust is subject to crushing than to "compressive extension"[1] in the former than in the latter case. This leaves a greater mass below the level of "no strain" which is suffering extension. The violent commotion that often disturbs the upper crust can not in the least affect the deeper masses. The only condition that seems competent to reduce the amount of extension beneath the land-masses would be so great a depression of the level of "no strain" as to leave less material below it subject to extension, and this the nature of the case as already shown, does not admit.

In reflecting on the subject we must bear in mind that the results above stated are only obtained by assuming as the temperature of original solidification of the crust a very high figure —in Mr. Fisher's investigation 7000 degrees F. This datum seems scarcely admissible when we recollect that material similar to that which composed the primeval crust now solidifies at about 2000 degrees F. Even allowing for the effect of undoubted greater pressure at that date and perhaps for some other conditions different from any now prevailing, it seems more in accord with physical laws that the original slaggy liquid cooled to a much lower degree before solidification took place. By changing this datum to 4000 degrees F. Mr. Fisher obtains only 0.7 of a mile as the present depth of the level of no strain, a result yet more discordant with the views of physical geology than the former, and in the face of known facts scarcely tenable.

Again, as said above, Mr. D. assumes an excessively high figure for the duration of the cooling process—175,000,000 years —a period which, though not impossible, is yet much beyond that which is usually believed to have elapsed since the epoch of consolidation.

Considering all these points it may be well to hesitate before yielding full and implicit acceptance of these new results of the mathematician. The physical geologist is grateful for all conclusions that his mathematical brethren can give him, but he

[1] Mr. J. M. Reade's term.

cannot always adopt them at their first publication. Though the rigid processes of their science admit of little or no dispute yet the final results are dependent on the data and on the form in which those data are supplied. And in the present problem some of these data are so uncertain that considerable doubt must attach to the final outcome from the mathematical mill. And when as in the case now in hand the conclusions are or seem to be at variance with accepted and apparently solid doctrines in the science, the geologist may be excused for hesitating before he accepts the mathematical deduction.

We will not now follow Mr. Davison into that part of his paper in which he treats of the elevation of mountains by the contraction of the cooling globe—a topic in which he is in direct opposition to Mr. Fisher—but at some future time we may return to the subject and state the arguments of the mathematician on this point.

THE POST-GLACIAL GEOLOGY OF ANN ARBOR, MICH.

BY C. W. WOOLDRIDGE.

Many students in the University of Michigan must have noticed how different is the character of the ground on which the city of Ann Arbor is built from that of the surrounding country, either upland or lowland.

The greater part of the city is built on a low hill with a flattened convexity of contour. The Huron river entering from the northwest crosses the city in a deep and picturesque valley. On the east side, between the city and the observatory hill, extending from the river half a mile or more to the southward, is, or was, a typical Kame formation, some of the best marked features of which, unfortunately, have recently been destroyed by grading. The western part of the city is crossed by a brook flowing northward to the river, which is formed by the union of two branches, one flowing from the southwest, the other from the southeast.

From the valley of this brook, the southwestern and southern border of the hill, on which the greater part of Ann Arbor is

built, is marked by a declivity from the foot of which spreads a flat valley broadening toward the southeast, in which direction it extends to lake Erie. The neighboring hills and uplands east, west, north, and across the flat to the southward, are composed of the boulder clay with here and there a bank of gravel or sand, due to its local erosion, but all over the city within the boundaries defined every excavation shows stratified gravel or sand, a deposit so different from anything else in the vicinity, and so extensive that it could not be due to any merely local or accidental causes.

In the summer of 1887 I began an examination of these deposits. Two deep gravel pits in different parts of the city having at that time freshly excavated faces, offered good sections for study. The first of these examined is excavated in the bluff facing the river valley two blocks east of the Michigan Central R. R. depot. This section faces the north but bends around on either side so as to face the west and the east. Its lower part through a depth of ten or twelve feet exposed above the talus is composed of a fine, nearly uniform and clean gravel, of pebbles averaging about the size of peas and beans. This is arranged in distinct beds of varying thickness, nearly horizontal in position but terminating in thin edges, overlapping each other. Each of these beds, however, is obliquely laminated as if it were built out from a shore by successive accretions deposited on its border, the pitch of that border being shown by these laminations. What surprised me was that the dip of these laminations is uniformly toward the south, that is toward the hill on which Ann Arbor is built, as if in that direction had been open water, while to the northward where now the valley of the Huron river is excavated to a depth of 50 or 60 feet below the level of these beds had been the shore.

Above these gravel beds is a stratum of bowlders ranging from pebbles the size of a hen's egg to blocks that would weigh a quarter of a ton, with barely enough of finer materials, gravel, sand, and clay, to fill the interstices. This bed is a distinct stratum five or six feet thick deposited in conformity with the gravel beds beneath it, and covered by the surface soil. Resting on the beds of finer gravel as it does, it seemed a strange deposit, for it is obvious that any current powerful enough to

have brought these bowlders here must have carried the gravel on which they rest. I could only account for their presence by supposing them the residue of some mass of bowlder clay which towered above the water close by, and had fallen upon these gravel beds as a land-slide, the finer materials of which the waves had carried away. A little farther west, where the western approach to the Michigan Central depot has recently been excavated, the cutting is made in bowlder clay which might be the stump of such a mass as could produce a bowlder bed in the way supposed; this clay seems to rise from beneath the gravel nearly to the hight of the beds which we have examined.

The other gravel pit available for study is in the northwestern part of the city. Here the principal face of the excavation fronts the southeast while its southern extremity bends round to face the northeast. This southern part of the cutting is excavated beneath an older gravel pit, and here deeper beds are exposed than elsewhere. The northern part of the cutting shows a section extending from the natural surface down to the beds exposed farther south. The total depth exhibited I estimated at 35 feet. These deeper strata are composed of sand, thin bedded, the layers succeeding each other at intervals of less than half an inch, having a very perceptible dip to the southward, and sprinkled thinly with pebbles ranging from the size of a butternut to that of the sand itself. These strata have the appearance of beds deposited on the slope of a lake bottom below the action of ordinary waves down which a few pebbles have slid from a higher level. Some of these beds have been cut away on the south side and refilled with similar beds having the same general slope as before. The junction between these sand beds and the gravel overlying them was hidden by a talus at the foot of the cutting in the northern part of this excavation, beneath which these sand beds enter with a rising slope of 10° or 12° toward the north.

Above this talus is a series of thicker beds of gravel similar to those examined in the other excavation. These beds are nearly horizontal and show oblique laminations dipping toward the south as before, but at this point a broad valley opens to the southward, while a short distance to the north rises the highest hill in the vicinity of Ann Arbor.

Above these beds of gravel is a bed of horizontally stratified material, here about ten feet thick, composed of mingled clay, sand and gravel. No stones larger than a hen's egg appear in any of these beds. I was inclined to attribute this surface stratum to the wash from land-slides which had fallen from the clay hill to the north, but on further examination I find that a surface stratum containing much clay and larger pebbles sometimes reaching the rank of bowlders, is spread quite generally over the Ann Arbor gravels. Some change of conditions must have attended the deposition of this surface stratum to produce this change of its character, but just what that change may have been I am not prepared to suggest. Elsewhere I have seen a similar condition of the surface stratum in yet more marked contrast to the sedimentary beds on which it rested, and I think that the phenomenon is general enough to be deserving of special study. I will sum up the results of my studies of the Ann Arbor gravels by saying that I have come to see in them a well marked example of an ancient delta. When these beds were deposited lake Erie extended over the site of Ann Arbor, which at that time was a bay near its western extremity. Into this bay the Huron river poured a turbid torrent from the, then naked, hills of bowlder clay to the northwestward, dropping its gravel as soon as it entered the waters of the lake, while its finer sediments were carried farther. This gravel and sediment formed the delta, now the hill; on which Ann Arbor stands. When the water subsided the river formed a new channel to the northward of an island, the northwestern extremity of which is now the observatory hill, and soon cut a gorge in the loose drift materials from which ravines extended on either side to shape the hills which now border its valley. There may very likely have been a shallow body of water retained in the old bay south of the Ann Arbor delta, and one of these side ravines making connection with that would drain that water into the river and thus cut the valley through which flows the brook in the west side of the town. I have looked for traces of the old shore line corresponding to the level of the lake when this delta was formed. At a few points along the hills which formed the southwestern border of the bay at that time are what may be traces of shore terraces

then formed, but they are very obscure, not likely to be noticed by anyone who does not know exactly what he is looking for and where to look for it. Along most of that ancient shore no such traces can be detected. In the neighborhood of the river the country must have been greatly transformed, since shores existed at that hight, but on the opposite side of the bay and the opposite border of the island mentioned, such changes might be expected to be less extreme.

From the fact that shore marks there are so obscure I infer that they were never strongly marked, or else that the earth in this region was then in a condition too loose and unstable to retain their traces.

NOTE.—Since the above was written, I have discovered evidence proving the existence of shore lines at two different levels, both passing through the site of Ann Arbor. The upper one of these coincides with the delta plateau above described, while the lower has left its trace in an obscure terrace noticeable at intervals along near the base of that plateau at a level about thirty feet lower. It is further evident that at the epochs of these shore lines the water margin in this region was a succession of deeply indented, land-locked bays, flanked and intermingled with an archipelago of islands, which have served greatly to complicate and obscure the traces now remaining of these shores. C. W. W.

A CORRELATION OF THE LOWER SILURIAN HORIZONS OF TENNESSEE AND OF THE OHIO AND MISSISSIPPI VALLEYS WITH THOSE OF NEW YORK AND CANADA.

BY E. O. ULRICH.

IV.

Beds XII. The strata comprised in this division are a little more than 200 feet thick in the vicinity of Cincinnati. Compared with beds XI, it is found that they differ considerably in the much greater abundance of calcareous material, the layers of limestone, particularly in the lower portion, being comparatively much more numerous, the ratio of limestone and shale being on an average about one foot of the former to two feet of the shale. The latter also appears more calcareous and weathers to a yellow or drab color.

Like beds XI, these also, mainly upon palæontological grounds, admit of division in two minor sections which I refer to as XII*a* and XII*b*. Of the 199 species mentioned in the list as occurring in beds XII, 113 are restricted to them, while only 58 are common to the upper and lower sections. Fifty-seven are restricted to XII*a*, and forty-six to XII*b*.

a. The thickness of this sub-division as seen in the hills surrounding the cities of Cincinnati, Covington and Newport is about 90 feet. In the lower 50 feet (exposed in the hills 270 to 320 feet above low water mark in the Ohio river) there is often a considerable amount of sandy material, the limestone layers being nearly all impure; and some of the layers might even be described as fine grained sandstones. The intercalated shales, too, are less fine grained and of lighter color than usual. Fossils of many species, principally bryozoa, however, are moderately abundant and in a good state of preservation. The most distinctive forms are distributed about as follows: The five feet at the base (*i. e.* 270 to 275 feet above low water mark) hold great numbers of *Callopora dalei*, *C. subplana*, and *Peronopora vera*, a species with larger cells than *P. decipiens*. The second of these species is restricted to this horizon, but the others range about fifty feet higher.

Twenty feet above the *C. subplana* bed many species make their appearance. Of these *Heterotrypa frondosa*, *Dekayia aspera* and *Homotrypa curvata* may be mentioned as particularly characteristic of the horizon. In the succeeding twenty or twenty-five feet fossils are comparatively rare though several of the layers are sometimes charged with more or less worn examples of *Orthis testudinaria*. It is in this portion of the section that the sandy feature of the sub-division is the most conspicuous. Many of the layers show peculiar trails and fucoidal markings.

The top of these layers is marked by a very persistent shell, the *Streptorhynchus planoconvexus*, which, though restricted to a vertical range of perhaps not over five feet, may be found wherever this horizon is exposed.

The remaining portion of the sub-division, *i. e.* between 320 and 360 feet above low water mark, furnishes the bulk of the rock used in constructing foundations at Cincinnati. Sub-crys-

talline limestone, of bluish color is present here in many courses, varying in thickness from three to ten inches. The intercalated shales are generally quite rich in fossil remains, causing the quarry dumps to be much frequented by collectors. The following are the most characteristic species of this horizon:

Glyptocrinus decadactylus Hall.
" *? shafferi* Miller.
Heterocrinus grandis Meek.
Hemicystites stellatus Hall.
Atactoporella mundula Ulrich.
Constellaria florida Ulrich.
Bythopora fruticosa Miller & Dyer.
Leptotrypa discoidea Nich.
Discotrypa elegans Ul.
Dicranopora internodia Miller & Dyer.
Ptilodictya falciformis Nich.
" *maculata* Ul.
" *pavonia* d'Orb.
Phylloporina clathrata M. & D.
Orthis bellula Meek.
" *ella* Hall.
" *fissicosta* Hall.
" *plicatella* Hall.
Platystrophia crassa James.
Streptorhynchus sinuatus ? Emmons & Meek.
Lingulella cincinnatiensis H. & M.
Holopea paludinaformis Hall.
Cyclonema bilix Meek (? Conrad).
Orthoceras dyeri Miller.
Cyrtoceras vallandinghami Miller.
Anodontopsis? unionoides Meek.
Proetus parviusculus Hall.
Anomaloides reticulatus Ul.

b. This sub-division embraces the upper 110 feet of beds XII. The whole is of a light blue color and consists of rapidly alternating layers of soft shale and limestone. The latter are generally in pure, very thin and irregularly bedded, (shelly) and charged with a profusion of animal remains, some sections of the beds being almost literally composed of fossils. Only a few of the limestones are thick and even-bedded enough to furnish desirable building rock, and, so far as I am aware, the subdivision is nowhere extensively quarried. Still the tops of the hills about Cincinnati, where much grading for streets and buildings has been done, furnish an abundance of excellent exposures of the lower fifty to eighty-five feet.

The highest of the Cincinnati hills (Mt. Auburn and Price hill) do not contain any of the upper twenty-five feet of the subdivision, and only a few localities in Ohio and Indiana are known where they may be studied. A creek, the name of which does not just now come to my mind, cuts through them at a point about one mile northwest of Manchester, Ind. They are also shown in Todd's fork near Morrow, O.; and in several small water courses near Lebanon, O. These exposures show that above the well known "Orthis bed" the fossils become

gradually much less abundant. The lithological features, however, are not remarkably different from those pertaining to the lower eighty feet.

The beginning of the subdivision, as shown in the Cincinnati hills, about 360 feet above the river, is marked by the first appearance of a number of easily recognized fossils, among them being *Strophomena fracta*, *Orthis sinuata*, *Platystrophia laticostata*, *Homotrypa obliqua*, *Batostomella gracilis*, *Monticulipora molesta*, and *Heterotrypa? vaupeli.* Of these the first and the last two are restricted to the lower ten feet, but the others range upward eighty feet or more. It is at about this horizon also that *Glyptocrinus dyeri*, *G. subglobosus*, *Ohiocrinus constrictus*, *Stenocrinus pentagonus* and *Iocrinus subcrassus* are found.

Between 370 and 380 feet above low water mark there comes in a bed holding countless shells of a form of *Strophomena* which, on account of its exceptionally heavy shell, is known to collectors under the name *ponderosa.* Many of its valves (usually the concave side) are encrusted by the delicate zoaria of *Stomatopora* and *Atactoporella*, but lamellibranchs, gasteropods and other brachiopods are almost excluded from the bed by the prolific multiplication of the *Strophomena.*

The next recognizable horizon occurs at an altitude of about 385 feet above low water mark. This might be called the *Strophomena nasuta* horizon, that restricted shell being very abundant here. From here on to the 400 feet level the shales, of a lighter color than usual, predominate. These shales present a wonderful development of life, the fossils being both beautifully preserved and of great variety. The class bryozoa, however, furnishes by far the greatest number of individuals as well as species. Fragments of *Callopora ramosa*, *C. rugosa*, *Peronopora compressa*, *Monticulipora cincinnatiensis*, *Heterotrypa inflecta*, *Dekayia appressa*, *Batostomella gracilis*, *Leptotrypa ornata*, *L. calceola*, *L. clavacoidea*, and *Cheiloporella flabellata* are more or less abundant. With one or two exceptions these species are also all restricted to this bed. Other characteristic fossils of this horizon are *Orthis jamesi*, *Bucania? costata*, *Ambonychia? jamesi* and *Anomalocrinus caponiformis.*

The last well marked and, perhaps, the best known fossil

horizon is the "Orthis bed" which comes in at an elevation of 430 to 435 feet above low water mark. This bed is generally several feet in thickness and remarkable chiefly because it contains great numbers of a very large and gibbous form of *Platystrophia lynx*. Occasional examples of this species or variety are met with both above and below this bed, but none are known to have been found beyond the limits of beds XII.

In Kentucky the lower subdivision of the series of strata here designated as beds XII form, almost exclusively, the surface rock of Campbell, Kenton, Boone, Gallatin, Grant, Pendleton and Bracken counties. In the range of counties to the east and west of those mentioned the upper subdivision and a portion of beds XIII still remain, while the upper members of beds XI come to the surface over a good portion of those abutting on the south. They form also a rather narrow strip of surface beyond the valleys of the Kentucky and Licking rivers, which, beginning on the western side of the group of counties mentioned, passes in a rudely circular manner through the counties of Owen, Henry, Shelby, Spencer, Washington and the northeastern portion of Marion; as a very narrow strip through Boyle into the extreme northern portion of Lincoln and the western portion of Garrard; from here into Madison, then on through Clark, Montgomery, Bath, Fleming and Mason into Bracken county.

The Kentucky geologists include the lower fifty feet (all below the *Streptorhynchus planoconvexus* horizon) in their middle Hudson, while the remaining 150 feet form the lower portion of their upper Hudson series.[1]

In Washington, Boyle, Lincoln, Garrard, Madison and Clark counties the strata of this division are decidedly arenaceous, the feature being much more pronounced and of greater extent than in Ohio and Indiana. In fact some portions of the lower subdivisions (which here, too, can not well be distinguished from the upper) may with truth be called sandstones. In these a

[1] I cannot see any good palæontological reason for the divisions proposed by the Kentucky geologists, and have in consequence not accepted them. The lithological peculiarities of these three divisions disappear rapidly to the northward of the central counties of the state, so that in Ohio and Indiana their strict identification is no longer possible.

few fossils occur as casts, but, being illy preserved and difficult to obtain, are not likely to be much sought for.

Above the *S. planoconvexus* layer, which is nearly always a well marked horizon, the fossils are quite plentiful, but the finer features of their external structure and ornamentation are generally obscured by adhering grains of earthy matter, or thin deposits of lime. Many also are silicified. Among a large number of the species which have been mentioned as characteristic of the division in Ohio, there are several which, so far as known, occur there only very rarely, or not at all, yet are very abundant in the Kentucky exposures. Of these *Rhynchonella fringilla* Billings (*Orthis linneyi* James), *Helicotoma helena* (Bill. sp.), *Ptilodictya hilli*, *Amplexopora cingulata*, *Heterospongia subramosa* and *Cyrtoceras conoidale* should be mentioned. Most of these species occur in beds which I hold to be very nearly equivalent to those exposed in the Cincinnati hills at an elevation of about 350 to 360 feet above low water mark.

(*To be continued.*)

GEOLOGY AS A MEANS OF CULTURE.

BY ALEXANDER WINCHELL.

I.

1. Introductory.

The editorial management of the American Geologist announced in the Prospectus, as an important feature, the intended publication of matter expressly suited to the needs of teachers of geology. Their plans also, embraced the presentation of views setting forth the true relation of Geology to educational work, and to general intelligence. It was believed such efforts would commend the science to all teachers and readers; and enlarge its acceptance and influence in the field of education. In view of the needs of teachers, it is intended to offer synopses, expositions, analyses, tables, schemes and other devices and matters of practical utility in the processes of instruction; and for this purpose, the editorial board anxiously await the accession of sufficient financial support to justify the employment of

illustrations on a generous scale. They believe the profession of teachers will respond to their efforts.

The editorial board are aware that a "departure" of this kind may be regarded as compromising the scientific standing of the journal. They hear it said there are too many popularizers dealing with scientific material at second hand; and that we want many more investigators and more original contributions. The writer of this is also of the opinion that original work should be actively and directly promoted; but with the founder of the Smithsonian Institution, he perceives that the best interests of science demand that knowledge be "diffused" as well as "increased." The diffusion of knowledge promotes its increase by multiplying the number brought into position to contribute by money and brains toward effecting the increase. When the diffusion is extended into the ranks of intelligent teachers, the best possible conditions of increase are brought into existence.

In the January Number of THE GEOLOGIST, was inserted under the general head of Editorial Comment a note entitled, "Geology in the Educational Struggle for Existence." It was intended to point out the nature of the rivalry which tends to restrain, especially in certain universities, that advance of geological studies which their inherent relative importance would lead us to expect. That note simply pointed out a state of the facts. How greatly the interests of education and general culture are made to suffer by the existence of such a state of facts the writer did not undertake to show. But the exposure of the facts ought to be followed by an exposure of their wrong and unreasonableness, and the injury which they inflict on the cause of education —an injury inflicted at such a stage of educational development as to result in permanent malformation and deformity. The present writer will attempt, therefore, to carry the discussion to its natural development, and will begin, in the present article, a candid examination of the relation which geological study sustains to symmetrical culture. To the positions here taken he invites the thoughtful attention of all teachers and all geologists.

2. WHAT IS MEANT BY CULTURE?

It is considered educational orthodoxy to maintain that educa-

tion, as the term itself implies, consists in such training of the human powers—but more especially the intellectual faculties—as will make them of greatest service to their possessor. If this expression means exclusively culture, and does not involve the acquisition of useful knowledge, it should at least be said that the acquisition of knowledge is one of the incidents of culture, and hence culture ought to be so sought as to involve the attainment of *useful* knowledge. For the present, however, the writer wishes to contemplate the purely cultural aspect of education, and to inquire how geological studies stand related to processes of pure culture.

In order that one's faculties may become most serviceable, they must acquire as far as possible, alertness, effectiveness and readiness. In other words, they must act with facility and rapidity; they must accomplish a large volume of their appropriate results in a given time, and must be ever ready to enter into action. They must be like a team which is quick, strong, and in harness.

What in detail, do educators contemplate when they speak of culture? What are the several powers whose alertness, effectiveness and readiness are best promoted by best culture? This is equivalent to asking what are the powers by whose most perfect activity we achieve most successfully the work allotted to us? The obvious answer is, all the powers by which a human agent seeks his ends—powers *physical*, powers *intellectual* and powers *ethical*. Let us restrict the inquiry, for the time being, to the powers intellectual. We will contemplate then, for the present, pure *intellectual culture.*

The term culture is much employed by a class of writers and speakers who extol lines of study demanding the exercise especially of *verbal memory*, and the power of comparison and analysis. The verbal memory is the faculty of retaining and recalling mere words. It is the means of acquiring names and of speaking them on occasion. It fixes phrases and quotations, and puts us in possession of them. It seizes on the words and forms of a foreign language, and makes them permanently ours. It is the spring of the faculty of verbal utterance; it confers effective power of expression. Its function extends to the retention of dates and other numerical expres-

sions. Self-evidently, the verbal memory is an important means in the acquisition and communication of all knowledge, and the attainment of all ends to which knowledge contributes. To add alertness, effectiveness and readiness to the verbal memory is one important factor in intellectual culture.

Verbal memory, however, appears to be psychologically analogous to the memory or reproduction of sounds and sights in general; and thus, for our purpose, the general power of reproducing percepts may be designated the *sense-memory*. This power in its further exercise, is that by which we recall the features of individuals, and attain an extensive acquaintance. It preserves what we have seen in the forms of matter in general—forms of animals, plants, scenery, architecture. Readiness of recognition is conferred by it, and therefore, power of detail in descriptions. It is the chief faculty of story-telling—so far as simple utterance is concerned. Facility in sense-reproductions confers many advantages; and it is often the means of attaining successes which a superior grade of reflective intelligence fails to win. Aside from the store of facts which it sometimes holds at the service of the other powers, it is the most available instrument for what we call popularity. Though the vice of the excessive exercise of sense-memory may be garrulousness, recital of meaningless details, the substitution of anecdote for thought, and general shallowness, yet it is quite manifest that the fullest exercise of the sense-memory can only be productive of advantages, if the judgment and other intellectual powers are brought into symmetrical and restraining development. The whole field of the sense-memory deserves careful exercise and strengthening, and this work must be one of the useful and legitimate elements of broad culture.

Embraced in the order of culture first referred to is the exercise of the power of *comparison and judgment*. Without affirming that these are one faculty, their constant association in activity leads me to speak of them as one process. In detection of likenesses and unlikenesses, we discover grounds for judgments. Every judgment pronounced is an assertion of congruity or incongruity. As every act is the explicit or implicit expression of a judgment, a ready facility in the apprehension of the grounds of judgments is a cultural acquisition of prime importance.

The power of ***abstraction*** is another factor in that intellectual effectiveness which attaches to the lines of study extolled by the same class of writers about culture. Abstraction is the contemplation of one thing apart from all other things. It is simply an effort of attention carried to complete success. Attention is specially indispensable in the search for relations which are not immediately obvious—relations between things inconcrete, or abstracted from tangible forms. Every continued process of reasoning depends on abstraction. All mathematical relations, mental powers and moral qualities are abstract. The power of abstraction is a faculty in constant demand, but especially in the higher efforts of thought. It is an important power falling plainly within the scope of general culture.

The faculty of ***deductive reasoning***, while constantly employed in many familiar modes of mental activity, is also one especially demanded in many of the higher efforts of intelligence. It is preeminently the faculty of mathematics; but it finds constant exercise in logic, in philosophy, in physics, and wherever principles or abstract truths are given, and their consequences or outcome are demanded. Obviously, mental culture must embrace the improvement of this royal power.

But deductive reasoning implies a power of retention of abstract truths or principles. This is often designated the ***philosophic memory.*** As an accessory and inseparable adjunct of ratiocinative processes, this power is indispensable in the higher mental activities; and its capability of perfect exercise must be one of the conditions of most efficient mental service. In other words, complete culture embraces an improved power of philosophic or thought memory.

It will scarcely be doubted that general culture involves the quickening of the ***imagination***, the training of it to moderation and consistency, and the employment of it as an adjunct in the efforts of memory and deductive reasoning. The picturing power of this faculty gives vividness to the reproductions of sense-memory, and readiness in the comprehension of descriptions. It is an invaluable instrument in the attainment of clear conceptions of the results unfolded by deductive processes. The interpretation of the results reached by mathematical reasoning often depends wholly on the illumination of the field of ex-

ploration by the light of this faculty. It goes before discovery, and discloses resting-places for thought in the midst of the gloom of the unknown. Its creative powers are often exercised under the promptings of analogy, congruity or contrast, and it thus becomes luxuriant in simile and metaphor. By its luminous apprehension of the forms and details of concrete things inaccessible to perception, it contributes to graphic description; and through its resources of metaphor, both illuminates the thought and garnishes the style. Imagination is therefore a powerful instrument in the creation of new conceptions and the transmission of them to the intelligence of others. A mind well fitted for the creation of new conceptions possesses one of the most effective gifts of culture; and if, in addition, it wields the power of graphic and pleasing elucidation, its cultural gifts are brilliant, attractive and useful. Assuredly, then, the imagination is one of the most important faculties to improve and strengthen by the arts of education.

I have mentioned the intellectual powers and processes somewhat in the order in which they are the subject of disciplinary exercise in the popular systems of "liberal" culture, rather than in the order of their importance or the order of their spontaneous development. Assurdly, however, the sense-memory would receive no content unless the *sense-perceptions* had been previously called into activity; and the picturing power of imagination would remain latent unless sense-perception had supplied the elements of its creations. Perceptions are the antecedents and conditions of sense-memory, of imagination and of induction. They are also the conditions of the awaking from slumber of those intuitive cognitions of necessary truths, which regulate and control all human actions. Perceptions, in other words, are the germinal elements of all knowledge and of all power of knowledge. In a more obvious sense, they are the sole means of communication with the external world. They find therefore a more constant, and more diversified and more essential use than any other of our intellectual powers. The most widely and variously exercised of our faculties are those which most demand the improvement of judicious culture. To learn how to observe most advantageously should be one of the chief ends of education.

The power of *inductive reasoning* should not be omitted from the list of those deserving of culture. Induction from observed data has been pronounced the characteristic modern method of attaining to scientific knowledge; and Sir Francis Bacon, very mistakenly, has been regarded, in cant phrase, as the founder of the inductive method. So far as this is true, it shows with what aim and method we must proceed, if we would enter into the spirit of the modern march of intelligence. So far as induction has been pursued from the earliest dawn of reflective thought, it shows what is the inflexible and changeless mandate of nature in the method of marshalling our powers for the search of truth. In either view aptness and good logic in the drawing out of general truths from many details of observation appear plainly to be essential ends of well balanced modern culture. Without the acquisition of this power, education is glaringly defective. Whether Baconian or Aristotelian, the method of induction brings order out of a universe of discrete facts, and lays the foundations of principles which we build into the fabric of natural science. Induction has more than a service to science to perform. Thousands of the grotesque and unreasoned *nonsequiturs* of daily life are but the outcome of hasty inductions; and some of these, as in the search for petroleum, gas, or coal, are neither harmless nor inexpensive. To train this generalizing power so that it serves us thoroughly and truly is the part of education in its cultural aspect. I emphasize this truth, because it is quite generally ignored in our prevailing forms of education, at the same time that its importance seems to be foremost.

In the advocacy of the popular form of liberal culture, we hear much of the creation of a good *taste*. The study of the ancient languages, it is claimed, with truth, tends to improvement of the taste. If I understand the meaning of this expression, taste is the perception and feeling of congruity or fitness n the realm of sensible things. It seeks congruity, and takes pleasure in it. It knows how to shun incongruities, and is distressed by their occurrence. A good literary taste knows what juxtapositions of thought are consecutive, graduated, and pleasngs and it knows what juxtapositions of words and phrases will avoid a jar, and best adapt expression to the thought. In music,

it appreciates and seeks such successional relations and harmonic combinations of tones as are congruous with each other and with our musical apperceptions; and such as are congruous with the thought of feeling which the composer seeks to express. A good artistic taste understands what forms and colors harmonize with the common forms of beauty and fitness implanted in the soul. It is preëminently *literary* taste which the prevailing culture claims to shape and perfect. Indisputably, such culture, besides increasing the happiness of its subject, confers a means of influence which improves the scholar's chances of success in the battles of life. Such control of the adversities of situation is therefore, eagerly to be sought in our professed systems of general culture.

The foregoing may be regarded as an enumeration and characterization of all the important powers which fall within the scope of intellectual culture. The term, so far as I know, is not employed, and cannot be employed, in any sense involving more than the educational discipline of these. What our linguistic and literary friends mean by "culture" cannot refer to any occult influences bearing in any other direction than the improvement of these powers. It seems superfluous to emphasize so plain a proposition; but it becomes desirable to bring to the light of day and to the terms of definite statement, the whole secret and mystery of "liberal culture."

It is intended next, to present an analysis of the content of geological science, and then an examination of the nature of the demands which it makes upon the powers of the student.

EDITORIAL COMMENT.

THE ANTIQUITY OF MAN; SOME INCIDENTAL RESULTS OF THE DISCUSSION.

"On earth nothing great but man;
In man nothing great but mind."

Such was the inscription placed by Sir William Hamilton above the door of his lecture room — very appropriate, too, for

a metaphysician. Geologists may also take a suggestion from it. The human element in our science goes far to keep it in relation with the current thinking of the world. That portion of geological time during which man has existed upon the earth is insignificant when compared with the whole record, yet in that relatively brief interval the chief interest centers.

The bare question, how long ago man first appeared, is not the only point of interest. Was the first man white or black, ape-like or human? Is the race a unit or of multiple origin? What continent witnessed the first human birth? These and many similar questions vibrate about the cradle of the race, and some of them are of greater importance than the mere lapse of years since the introduction of man.

Thc perennial interest in the antiquity of man constantly brings this topic to the front in spite of the frowns of those geologists who deprecate any attempt to express geological time in years. And the discussion justifies itself, if not by settling the main question, at least by throwing much light upon other incidental questions. When it was found that man was contemporary with many species of extinct mammalia, the question how long ago these species became extinct assumes new importance. As a consequence of the impulse thus given we know more about the time of disappearance of the Quaternary mammals than we should otherwise have known. They are found to come to a later period than was at first supposed.

In like manner the association of human remains with the Glacial period has caused the remoteness of that period to be sharply called into question, with the same result of bringing it nearer to our own times. Mr. James Croll at first put it in the phase of great eccentricity of the earth's orbit which occurred 980,000—720,000 years ago. In other words he thought the Glacial period began about a million years ago and lasted a quarter of a million years. Later he placed it in the eccentricity phase 240,000—80,000 years ago.

These dates are astronomical and have not been generally accepted by geologists. Still they served to give a measure of definiteness to the common impression that the Glacial period was very remote. In the light of new evidence these great figures have shrunken to modest dimensions. In the August

number of the Quarterly Journal of the Geological Society, Prof. Joseph Prestwich concludes that "the epoch of extreme cold may come within the limits of 15,000 to 25,000 years, and the Post-Glacial 8,000 to 10,000 years. This might give to palæolithic man, supposing him to be of so-called pre-glacial age, no greater antiquity than perhaps about from 20,000 to 30,000 years; while should he be restricted to the so-called post-glacial period, his antiquity need not go further back than from 10,000 to 15,000 years before the time of neolithic man."

Prestwich bases this conclusion partly upon the new data of glacial movement. It is found that while the Alpine glaciers flow about 300 to 400 feet annually, those of Greenland flow at the amazing velocity of 6,000 to 16,000 feet annually, *i. e.*, about forty times as fast. The conditions in Greenland are far nearer those of the Glacial period than are those in the Alps. The result is to reduce the period of glaciation, since the work was done so much more rapidly than was previously supposed. In like manner the more accurate investigation of the gorge of Niagara has reduced the time of its erosion to 6000 or 7000 years. The whole drift of opinion is decidely towards a very moderate estimate of Quaternary time.

Shall we see the same result in respect to the Tertiary? In the Nineteenth Century for November 1887 Mr. Alfred R. Wallace reviews the American evidence of human antiquity, dwelling especially upon the California finds which associate man with the Pliocene period. He deplores the skepticism which has hitherto excluded this evidence. But it is better to be over-skeptical than over-credulous. The reluctance to admit the proofs of Pliocene man has led to the same sharp scrutiny of the age of the auriferous gravels which has been so beneficial in the cases mentioned above. May not the Pacific slope have run so different a course of development that the so called Pliocene there overlaps the Quaternary of the Atlantic slope? Already we have the opinion of Dr. Alexander Winchell, in the March number of this journal, that the great western outflows of lava occurred in the Glacial period, and of Gilbert and McGee of the U. S., Geological Survey that the Equus fauna should also be co-ordinated with the same period.

The general result of the controversy about the antiquity of

man has been to correct the estimates of geological time. Let the discussion go on. Let us not discourage it even by the suggestion that it is beneath the dignity of the true geologist to make estimates of geological time in years.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Considerations sur les fossiles decrits comme Algues. By G. MAILLARD. (Abhandl, Schweizer, Paleontol, Gesell, vol. XIV. 1887. Basel and Geneva, pp. 1—40, pls. I—V.)

One of the most valuable contributions which has lately been made to paleontological science is that of M. Maillard, curator of the museum of Annecy, on those fossils described as algæ.

After reviewing briefly the history of the synonymy of these organisms, so many of which are "problematic," the author divides them according to superficial characteristics into two categories:

1. Those in the form of simple semi-cylindrical or more or less flattened elevations occurring on the lower surface of the strata, and which are identical with the matrix in chemical constitution, grain, and color, *without any mixture of a foreign substance peculiar to the presence of the fossil;* they cannot be isolated from the strata, but comprise simple contour or bas-reliefs on the under side of the strata. These forms which he calls "demi-reliefs" include (a) most of the palæozoic forms, such as Crossochorda, Cruziana, Harlania, with perhaps Spirophyton and Alectorurus; (b) Helminthopsis, Gyrochorte and Cylindrites in the mesozoic; (c) the Helminthoidæ, Palæodictyon, and Münsteria in the Tertiary.

The second category includes those which may be isolated from the rock, and which are more often cylindrical or membranaceous, evidently more or less flattened by pressure, and whose composition differs somewhat from that of the matrix by the presence of some foreign substance which is confined to the fossils themselves, or at least is found in a smaller degree in the surrounding matrix. Such are (a) in the Jurassic, Chondrites, Theobaldia, probably Discophorites and Gyrophylites, Taonurus (Cancellophycus and Zoöphycus), Nulliporites (Chondrites) hechingensis; (b) Chondrites, Taonurus, Caulerpa, Sphærococcites, Discopharites and Gyrophyllites in the Cretaceous; and (c) in the Tertiary, Chondrites, Caueerpa, Tænidium, Halymenites, Hormosira, Sphærococcites, Gyrophyllites, Nulliporites, Aulacophycus, and Taonurus. The author calls especial attention to the fact that these two classes are quite distinct and that there is no transition between them, thus indicating a different origin.

Reviewing Nathorst's experiments with worms, pebbles, twigs, etc., by which he reproduced so many problematic genera, he shows conclusively that these artificial algæ are always found on the lower surface of the strata, never penetrating into the substance of the rock, but always appearing in "demi-relief." He observes that they possess the precise characters of the first category, a fact of much importance. With regard then to so many as fall into this list he agrees with the opinions of Dr. Nathorst, unless it may be concerning Cruziana, whose form is unlike the traces of any known animal.

By fossilization in "demi-relief" Mr. Maillard means the natural mould of an impression. It is a bas-relief and like the latter it can only be superficial. After discussing the observations and evidences brought forward by Saparta to show that these demi-reliefs are fossil plants, he insists that if these plants could fossilize in demi-relief, it ought to constitute wherever it occurs a generality; and, secondly, that these reliefs should occur on the upper face of the strata since the contrary is at variance with the laws of fossilization. On the other hand their presence on the inferior surface proves that, under the probable conditions of deposition, there must have been creases or moulds in the matrix which were filled by sediment, and which were made by a mechanical agent whose nature may or may not have been organic. Accordingly he excludes all those forms in "demi-relief," which constitute the first category, from all possibility of vegetable origin. Passing to the second category the author calls attention to the fact that none of the genera in the first ever contain characteristics of the other, and that, while the representatives of the first do not show the least evidence of a chemical or mechanical difference in structure from the matrix, in the other by careful experiment he has never failed to show a difference of composition. To this he has brought further evidence by the use of the microscope, showing in many cases the arrangement of the cells as well as a typical dichotomy.

It is impossible to give here an outline of the author's discussion of the occurrence and habitat of fossil Algæ, or the conclusions as to the nature and affinities of those problematical species to which he devotes special consideration. Enough has been said to form a suggestive hypothesis for observation. As to the former, he favors the transportation theory; in the latter he argues that all attempts at a systematic classification are at present futile since not more in fossil than in living algæ can species or genera be based merely on form; but that larger series must be used, combining also the study of the cells, the fruits, and the correlation of the organs. Instead of speaking of genera or species of fossil algæ, he urges that, except in perhaps the Diatomaceæ, and those calcareous algæ in which the structure is preserved, the use of the word *form* be adopted. In concluding the memoir he gives five well executed plates illustrating his categorical classification by artificial "demi-reliefs," formed by the method employed by Nathorst, as well as by traces of tertiary animals and true fossil algæ.

Synopsis of the flora of the Laramie group. By LESTER F. WARD. Pages 399—557; plates xxxi—lxv. (Accompanying the sixth annual report of the director of the U. S. geological survey.)

The history of the discussions respecting the age of the Laramie group occupies nearly thirty pages at the beginning of this memoir. Lying between the previously recognized Cretaceous and Eocene systems, its flora is thought by Lesquereux and others to be most allied with the latter, while its fauna is closely related to that of the Cretaceous. With its representation of earlier and later phases respectively of animal and plant life, it supplies a bridge across what had been regarded as one of the greatest breaks in geologic time.

The Laramie group is defined as an extensive brackish-water deposit situated on both sides of the Rocky monntains and extending from Mexico far into the British North American territory, having a breadth of hundreds of miles and representing some 4,000 feet thickness of strata. When this deposit was made, its area was an immense inland sea cut off from the ocean by intervening land areas, through which, however, it is believed that one or more outlets existed communicating with the open sea at that time occupying the territory of the lower Mississippi and lower Rio Grande valleys. This Laramie sea existed during an immense period of time and was finally but very gradually drained by the elevation of its bed, through nearly the middle of which longitudinally the Rocky mountains and Black hills now run. The exceeding slowness of this event is shown by the fact, clearly brought out by Dr. C. A. White, that the marine forms of the underlying Fox Hills strata, as they gradually found themselves surrounded by a less and less saline medium on the rising of the intervening land area, had time to become transformed and adopted to brackish-water existence, while these new-formed brackish-water species, when the sea at length became a chain of fresh-water lakes, had time again to take on the characters necessary to fresh-water life.

Remains of the vegetation of the Laramie age occur far more abundantly than do those of any of the other forms of life. In its swamps were formed extensive beds of peat, and its vast marshes were densely covered with cane, bamboo, and scouring rush, the thick accumlations of which are now preseved in its beds of coal, chiefly lignite. These are usually overlain by strata rich in fossil plant remains, showing that the rate of subsidence had then exceeded that of the growth of the deposit and the shallow sea had gained access, burying the last of the plants under its siliceous or argillaceous precipitations where they are preserved. In numberless places the profusion of leaves is so great that there is too little rock between them to render it easy or even possible to separate them and obtain complete specimens.

The presence of palms, Ficus, Cinnamomum, and other tropical genera in the southern portion of the Laramie area, while its northern portion has many species of Populus, Corylus, Viburnum, and other genera common to cold climates, indicates, as the author believes, a greater

difference of climate than can be accounted for by the difference of latitude. In explanation of this it is suggested that the nearness of the ocean on both the east and west sides of the southern portion of the Laramie area probably contributed much toward producing its equable and moist climate, nearly or altogether free from frosts. Farther north there is evidence that the Laramie period included a change from a warm to a comparatively cold climate.

All the species of plants that had been authentically described and recorded up to the date of this memoir in the Laramie group, in the Senonian of the upper Cretaceous, and in the Eocene, are enumerated for comparison in a very elaborate table, which fills more than seventy pages, including 1,540 species, of which 1,254 are phenogams. Among the phenogamous genera in the Laramie group are Sequoia, represented by six species; Taxodium, three species; Thuya, two; Sabal, four, and thirteen other species of the palm family; Populus, twenty-three; Salix, three; Quercus, twenty-three; Corylus, five, including the two species now living in the northern United States and Canada; Alnus, two; Betula, three; Juglans, eight; Platanus, eight; Ficus, twenty; Laurus, six; Cinnamomum, four; Cornus, four; Aralia, four; Rhus, five; Acer, three; Sapindus, four; Vitis, five; Rhamhus, twelve; Nelumbium, two; Magnolia, six; Fraxinus, two; Diospyros, four; and Viburnum, fifteen species. In total the Laramie flora enumerated in this table comprises 323 species, of which 275 are phenogams, 226 being dicotyledons.

The author remarks that the flora of the Laramie group furnishes evidence of having descended more or less directly from that of the Cretaceous of this continent, and that in many cases the lines of descent can be traced through the upper or Senonian beds to those of the Dakota group or American Cenomanian. The diversity of floras now existing upon the earth's surface has its analogue in the diverse but at least approximately contemporaneous floras of past periods through the Tertiary and Mesozoic eras, but in gradually diminishing degree, until in the Carboniferous period a nearly uniform flora overspread the entire globe. But much of the present extraordinary variety in the floras of different countries is attributable to the special agency of the successive glacial epochs which have occurred since Tertiary time, driving the floras southward and out on the southern plains to be destroyed on the return of warmer climatic influences or compelled to intrench themselves upon the summits of the mountain ranges, while new and constantly varying forms became developed to take their places in the lowlands.

After extensive detailed comparisons of the species tabulated, the author decides that the Laramie flora as closely resembles the Senonian as it does either the Eocene or the Miocene.

Portions of Mr. Ward's collections of Laramie plants, made in 1881 and 1883, were illustrated in the plates accompanying this memoir, which present eighty-four new species, not contained in his table, with fifty-six that were before known. The localities of their collection are briefly noted, but their descriptions and critical comments upon them were not

then in readiness for publication; and these have since been supplied in Bulletin No. 37 of the U. S. geological survey, entitled *Types of the Laramie flora*, containing 115 pages and 57 plates, on which the same figures are reproduced. Both these reports are preliminary to the author's forthcoming monograph. Among the new species the genus Populus claims ten; Quercus, two; Corylus and Alnus, each one; Betula, two; Platanus, one; Ficus, five; Ulmus, four, all from a single locality in Montana, being the first record of this genus in the Laramie flora; Vitis, four; Celastrus, seven, again constituting the first Laramie record of the genus; Grewiopsis, five, only two species having been previously recorded in the Laramie; Pterospermites, three, its first Laramie record; Cocculus, Liriodendron, Magnolia, and Diospyros, each one; and Viburnum, ten. Only two of these genera, namely, Grewiopsis and Pterospermites, have become extinct.

The similarity of the early types of phenogamous plants with those of the present time is well shown by their occurrence in the Laramie flora, including the author's table and his later additions, of seventy-four phenogamous genera that are still living, while only twenty-two have perished, nine of these last indeed being scarcely distinguishable from their present generic representatives in the living flora. Not so many as a half dozen phenogamous species, however, have come down to us from the Laramie period, nor in total from the Eocene, Laramie, and Senonian floras. Four, all belonging to the Laramie, are so recorded. These are well known species of our northern temperate flora and limited to North America, namely, the two common species of hazel-nut, the butternut, and Viburnum pubescens, Pursh.

On an Archæan plant from the white crystalline limestone of Sussex county, N. J., By DR. BRITTON. (Annals, N. Y., Acad. Sciences, vol. IV, February, 1888, pp. 123—124, pl. VII.)

In one of the detached areas of the white crystalline limestone in Sussex county N. J., Dr. Britton has found black filmy bands of graphite parallel to the bedding of the limestone. These bands reaching in some cases a thickness of 0.5 mm. and measuring about 3 mm. in width, are found in broken fragments averaging about 6 cm. in length, apparently having formed matted patches which are now transformed to thin strata of carbon. Though it seems probable that mineralogists as well as paleobotanists will question its vegetable nature, and protest against its addition to the already large number of problematical organisms, still, whatever its ultimate fate may be, it enjoys today the distinction of being the the oldest impression that has yet been referred to the vegetable kingdom. Without attempting to indicate a more definite affinity than its probable relation to the Algæ, Dr. Britton has figured and named this new species, in honor of Dr. Newberry, as *Archæophyton newberryanum*.

Geological Survey of Ohio, Vol. VI, Economic Geology. EDWARD ORTON, state geologist.

The bulk of this volume is devoted to petroleum and natural gas, with valuable chapters on salt, bromine, cement, gypsum, lime etc., To the

citizens of Ohio, looking for practical information and tangible results these economic investigations will possess the greatest interest and value; but to the GEOLOGIST at large, the first chapter, "The Geology of Ohio Considered in its Relations to Petroleum and Natural Gas," will sound the key note and absorb most attention.

Prof. Orton has made considerable changes in the geological column as previously published in the Ohio Reports. Following is a table of Newberry's arrangement (Ohio reports, I 88) set side by side, for easy comparison, with Orton's present arrangement.

	NEWBERRY.	ORTON.
Carboniferous.	Upper Coal Measures. Barren Measures. Lower Coal Measures. Conglomerate. Lower Carboniferous limestone. Waverly.... { Cuyahoga shale. Berea grit. Bedford shale. Cleveland shale. }	Upper Barren Coal Measures. Upper Productive Coal Measures. Lower Barren Coal Measures. Lower Productive Coal Measures. Conglomerate. Sub-carboniferous limestone. Waverly { Logan.. { Shale. Sandstone. Conglomerate. } Cuyahoga shale. Berea shale. Berea grit. Bedford shale. }
Devonian.	Erie shale. Huron shale. Hamilton. Corniferous.. { Sandusky limestone. Columbus limestone. } Oriskany sandstone.	Ohio shale { Cleveland shale. Erie shale. Huron shale. } Hamilton shale. Devonian limestones.
Upper Silurian.	Helderberg—Waterlime. Salina shale. Niagara { Hillsboro sandstone. Niagara sandstone. Niagara shale. Dayton stone. } Clinton. Medina.	Lower Helderberg limestone. Niagara... { Hillsboro sandstone. Gueiph sandstone. Niagara limestone. Niagara shale—Dayton stone. } Clinton. Medina.
L. Silur.	Cincinnati group { Lebanon beds. Eden shales. Point Pleasant beds. }	Hudson River series. Utica shales. Trenton limestone.

Beginning at the bottom the first change we observe is the omission of the Cincinnati group, a term so familiar in the geology of the great interior of North America that its absence occasions a slight pang. It was used by Meek and Worthen to designate the western equivalents of the Hudson and Utica shales; and Newberry added the Point Pleasant beds which belong to the Trenton. Orton finds the Utica shales absent at Cincinnati; though they prevail widely in northern Ohio, as shown by the numerous deep borings for gas and oil, and, relegating the Point Pleasant beds to the Trenton, the remaining element of the Cincinnati group is simply the Hudson river shales. The Cincinnati group is therefore dropped as being synonymous with Hudson, which has the priority.

The only weak point in this reasoning is that the Utica may not be

wanting at Cincinnati. Its absence is affirmed by Orton upon lithological grounds, but Ulrich maintains upon palæontological grounds that it is present.[1]

Next we note the omission of the Salina group. It was introduced by Newberry on the supposition that the gypsum beds near Sandusky were between the Waterlime and Niagara. Orton finds them to be "buried in the middle, or above the middle" of the Waterlime. In New York gypsum is found in a similar position in the Salina.

Next comes the omission of the Oriskany, which never had a secure footing in Ohio geology.

A more radical change appears in placing the Cleveland shale in the Devonian instead of the Carboniferous, and massing it with the subjacent Erie and Huron shales, giving to the whole the name Ohio shale. All this seems to be in the interest of simplicity and accuracy, since the former reference of the Cleveland shale to the Carboniferous was due to its correlation with the Waverly Black shale, designated in the above table as Berea shale.

The addition of this Berea shale is the next change; and the last one of any importance; the introduction of the Logan group, is also an addition.

Most of the changes are omissions, and they are commendable as tending to simplify the Ohio column, and to render its correlations with other states more obvious. About the propriety of these additions there is more doubt. Newberry gave the name Cuyahoga shale to all that part of the Waverly above the Berea grit. The right of priority may be invoked in protest against setting aside, or largely subtracting from, the term as thus defined. It would be more just to the author of that term, as well as more simple and lucid, to retain it with all its original breadth using Berea shales and Logan shales, sandstones, and conglomerates merely as descriptive subdivisions.

Newberry was perfectly aware of the existence of the Berea shale, and deliberately included it in his Cuyahoga shale. (Ohio reports II 88). He also indicated varying lithological phases of the upper strata of his Cuyahoga, (Ohio reports, II 87) and since there is absolutely no palæontological distinction between the Cuyhoga and the so-called Logan, the presence of a conglomerate not distinctly indicated in Newberry's definition of the Cuyahoga does not render that definition so defective as to justify the complication of new names within the interval originally covered by the term Cuyahoga.

Prof. Orton announces important results in structural geology. The Cincinnati anticlinal trends *northwest* instead of *northeast*. Some of the sharpest foldings in the state occur in the Northwestern counties, where the level surface and heavy cover of drift prevented any suspicion of their existence. Orton is a strenuous advocate of the theory that these disturbances are essential to oil and gas production.

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[1] See this Journal, May, 1888, p. 315.

Beginning at page 96 in Chap. II, we find a valuable discussion of "rock pressure of gas." Orton rejects the theory that this pressure is due to expansive force of the gas; also the theory that it is due to the weight of the superincumbent rocks; and thinks the true cause is hydrostatic pressure of subterranean waters, the same cause which produces artesian wells.

Chap. III, on the Trenton limestone will set prospectors everywhere to inquiring, "How far must we go to reach the Trenton?" But even if they reach it the search will generally be in vain, for Orton shows conclusively, by numerous analyses, that the Trenton is a gas or oil rock only when it has the composition of dolomite.

Chap. IV on the Berea grit is of greater interest to the geologist than to the oil operator, since the latter does not find much encouragement from this horizon. The extent and continuity of the Berea, as shown on the map p. 313, are truly surprising for so thin a stratum.

"The Ohio Shale as a Source of Gas" is the subject of Chap. V. This stratum is probably the richest in the state, the amount of oil per square mile having been estimated at 10,000,000 bbls., notwithstanding it is practically of little value as an oil and gas rock. Low-pressure gas is obtained from it in many places, but no great wells.

Chap. IX on measurement of gas wells, by Prof. T. W. Robinson is a valuable contribution to knowledge.

Chap., XIII, "Natural and Artificial Cements" by Prof. N. W. Lord is interesting and valuable, equally to the scientist and the practical man.

Chap. XV, by Edward Orton, brings out much new matter in regard to the production of lime, an industry which has been well nigh revolutionized by the introduction of natural gas.

Many other portions of this work equally worthy of commendation must be passed without mention for lack of space.

A careful persual of this volume will convince every one that the royal opportunities afforded to the geologist by the immense number of wells put down in search for gas and oil since the opening of the Findlay field, have been wisely used, and the interests of our science are there in able hands.

CORRESPONDENCE.

The Huronian of Canada. On page 238 of the AMERICAN GEOLOGIST (vol .I, No. 4,) Mr. S. A. Miller refers to Alexander Murray and the "Huronian series," and says: "If he had read Emmon's *Taconic System* it is difficult to conceive why he should have hesitated in referring the rocks to that system;" and Mr. Miller further says: "The word Huronian is therefore a synonym for Taconic."

I think Mr. Miller would scarcely have made such a statement had he

ever studied what we know as Huronian rocks in Canada, and which owing to the often impossibility of separating them from the Laurentian, we have latterly included under the name pre-Cambrian.

The Huronian of Canada is, so far as we know, wholly unfossiliferous, and largely metamorphic, and is unconformably overlain by rocks of lower Cambrian age.

Now I have heard a great deal about the Taconic system but have never used the name, being unable to make out precisely what it was. Recently, however, Mr. Marcou has defined his view of the Taconic,[1] which appears to be very different from that of Mr. Miller, while Professor Walcott seems to regard it in very much the same light as I have been obliged to regard the "Quebec group," and I may say that I fully concur in Mr. Walcott's views. Some of Mr. Marcou's Taconic near Quebec is certainly newer than Trenton limestone while Mr. Miller's Taconic commences below the Potsdam. These wide differences of opinion as to what Taconic really is are, I think, a strong argument in favor of adopting Professor Walcott's views on the "Use of the name Taconic," as expressed in the American Journal of Science, May, 1888.

ALFRED R. C. SELWYN.

Ottawa, June 1, 1888.

Lake beaches at Ann Arbor. Dr. Wooldridge and I have gone over the beaches in the region of Ann Arbor. I fully concur with him that the Ann Arbor terrace is one of construction at the mouth of the Huron River (of that time) which now bends abruptly there. In short it is rather a terrace delta deposit between clay islands; and the cut terrace plain below, or the old lake bottom extends for some miles. Yours, etc.,

J. W. SPENCER.

Dr. Wm. Clark of Berea, O., has been continuing his enthusiastic and successful researches in the Ohio shale and has now the most remarkable collection of fossil fish (?) that has perhaps ever been brought together in America. He is already known to palæontologists as the discoverer of the huge fossil described by Dr. J. S. Newberry at the meeting of the B. A. A. S. at Montreal, in 1884, and on which in honor of the finder was placed the name *Titanichthys clarki*. This measures about fifty-six inches across the head-shield and was the largest relic of a so-called fish that had, up to that date, been obtained from any part of the world. But the labors of 1886 and 1887 have been rewarded by other specimens of parts of this monster — a second head-shield surpassing the first and measuring seventy-one inches in breadth by 69 inches in length — a mandible thirty-five inches long with perfect alviolar process and groove — a pair of mandibles, right and left, thirty-four inches long by five inches deep — a fourth nearly perfect and thirty-one inches in length — and the anterior portion of a fifth, twenty inches long carrying a perfect tooth, and the base of a second in the socket. To these we must add a large median

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[1] Memo. of the Boston Soc. of Nat. Hist., vol. iv, March, 1888.

and two lateral dorsal plates of the same species of *Tracosteus clarki*. There are two mandibles set with teeth in position close and sharp, round in section, smooth, and about one-eight of an inch long. The head-shield shows the orbits, four inches in diameter, complete. There are also fragments of a second with the head bones separate and four tubercular plates, each tubercle of which ends in a spinous point. The upper premaxillary, part of which only is present, ends in two hooklike teeth. The largest tuberculated plate measures seven inches by nine, and the specimen is about fifteen inches over all in width. The most remarkable "find," however, of 1887, consists of two fossils so different from anything yet known as apparently to be the types of a new family. The first of these has a very elongated narrow body, resembling that of a gar-pike in general form. The snout is sharp, with a projecting tip and narrow, with long slender jaw bones, set with minute teeth of cladodont type, but very small. The front of the mandible is furnished with a large cutting tooth. The body was covered with very narrow, lozenge-shaped ganoid scales. Only two fins are present, set well forward, behind the head, with rounded ends and very strong rays. This specimen measures seven inches from tip to tip of these rays. Posteriorly, the body which is about twenty inches long tapers slightly with indications of a small caudal fin, but the actual end has not been preserved.

The second fossil is broader and shorter, with heavier jaws, stronger, coarser, and more numerous fin-rays, and measures eight inches over the two fins, by twenty-four inches in length. It shows some signs of an ossified spinal column. The ganoid scales have projecting points which fit into grooves in those adjoining them. Of this form there are several specimens, showing the head and fins. The range in size of the species, is shown by one of these, which measures twenty-four inches across the fins, each of which is nine inches long. The hinder end, which is well preserved, apparently terminates in an expanded and laterally flattened tail (as the flukes of the whale), showing some indication of a caudal fin.

Dr. Clark has also obtained two crania of a Dinichthys, apparently new, and four mandibles, (one nearly perfect,) two premaxillary teeth five inches long, and four lateral or cutting teeth four and a half inches long; a pair of ventral plates, a pair of clavicles (?), a pair of unknown bones found with the rest, and a large number of plates, probably belonging to *D. Tirelli* or to *D. Herzeri*, some of which have been entirely unknown hitherto.

In the same collection is a new (?) placoderm with mandible about twenty inches long and dorsal plates measuring nine inches by seven, having a very short crest and no neck, thus differing from those of *Dinichthys*.

All the above were found in the Cleveland shale of the *Ohio Geological Survey*. Those yet to be mentioned came from the Cuyahoga shale and are (1) a fossil about two and a half feet long, the jaws of which show cladodont teeth, but this, if not new, has not yet been identified. (2.) A

number of large, flat, pavement teeth of type hitherto unrecognized, and (3) a nnmber of slabs showing teeth and finrays of cladodont fish. (4) A *Ctenacanthus* spine, associated with dermal ossicles; (5) coprolites, and (6) some nearly entire and one entire palæoniscoid fish. All these are from the black base of the Cuyahoga shale (Berea shale of Orton) a bed that has hitherto yielded little besides *Lingula* and *Discina*.

E. W. CLAYPOLE.

Cleveland, Ohio, May 15, 1888.

Mr. J. S. Diller of the U. S. geological survey has kindly sent to me, for comparison with the Nebraska deposits described by Prof. Aughey, the following specimens:

Slide No. 1.— Volcanic dust from the eruption of Krakatoa, collected on Italian man-of-war Adriatico, 200 miles south of Java.
Slide No. 2.— Dust collected by Prof. J. E. Todd, Knox Co., Neb.
Slide No. 3.— Dust collected by Prof. J. E. Todd, Seward Co., Neb.
Slide No. 4.— Dust collected by Col. Sizer, Phillips Co., Kas.
Slide No. 5.— Dust collected by J. A. Udden, Lindsberg, Kas.

I find no important constant difference between the undoubted volcanic dust and the other slides 2, 3, 4, and 5. No. 1 is somewhat finer and contains more granular and fibrous particles mingled with the thin flakes which constitute the unique feature of all the specimens.

An important point of resemblance is that these flakes, although so thin, have *air-bubbles* inclosed in them. These are spherical, oval, spindle-shaped, narrowly elongated, &c. I found them in all but the Lindsberg specimen.

Nos. 3 and 5 contain diatoms.

The presence of air-bubbles favors the theory of volcanic origin. However, I regard the question of origin as not absolutely settled until the stratigraphy of this dust stratum and the associated strata has been thoroughly worked out in the field. This stratum may prove to be an important datum plane for the correlation of other strata.

L. E. HICKS.

In the AMERICAN GEOLOGIST for April, page 258, in a notice of N. S. Shaler's preliminary report in sea-coast swamps of the eastern United States it seems to be inferred that the beaches along the southern shore of Long Island are the result of marine action. If so, this is far from being the fact, as the truth is, these so-called sea beaches are being worn away by the waves rather than being formed by them, as the sea is yearly gaining on the land. Several years of careful study of the drift phenomena of Long Island by the writer, led to this conclusion that these beaches were formed by sub-glacial currents and not by the sea as has been supposed. Streams issuing from the front of the glacier laid down the stratified deposits of the south side of the island and it will be noticed that these southern projections of land, or beaches, are always the most prominent where the floods were the greatest. For instance at Fort

Hamilton, where the waters broke through the front of the Terminal Moraine, the southern ridges are very conspicuous, ending in the beach prolongations of Coney Island. Between this point and Jamaica, the beaches are less marked as the sub-glacial streams were not so great, but at the latter place where the floods came through from Flushing bay, on the Sound, we have the great Rockaway Beach formation, and so on until the east end of the island is reached, although the beaches on the east end are not so prominent as on the west end, as the gulf stream sweeping round the end of the island wears them away, carrying the detritus to the westward and sometimes filling in the mouths of old channels or inlets. From the front of the terminal moraine to the sea the plain is full of dry depressions, swamps and marshes representing old water channels, as the streams rising from the front of the ice-sheet or *under* it never flowed in a direct course to the ocean, but divided and subdivided and ramified in such a way as to form the ridges or beaches in question. These beaches have generally been held to be of marine origin, but this idea is being abandoned. Of course, along ihe ocean front these beaches have been somewhat modified by the action of marine currents, but their original formation was not due to this cause. This can be easily seen by anyone familiar with glacial or sub-glacial formations. Near the front of the ridge or terminal moraine the old channels are generally dry, but toward the bay or bays they become swampy and marshy where the channels have been kept open by the inflowing tides. The theory of oscillation has been brought into account for these phenomena on the south side of Long Island and in fact along the whole sea-coast, but this also is being abandoned. There are extensive marshes along the north side as well as the south side of the Island, and the same streams that formed one formed the other, as during the glacial age they were all connected.

The stratified drift south of the terminal moraine offers a field for interesting study, as the phenomena connected with it, as yet, are very imperfectly understood. The writer has prepared a paper describing it as studied on Long Island, and attention is only called to it here that others might take up the same thought.

JOHN BRYSON.

Louisville, Ky., June 13, 1888.

PERSONAL AND SCIENTIFIC NEWS.

AT THE LAST MEETING of the Minnesota Academy of Natural Sciences, at Minneapolis (June 11), a paper by Mr. W. J. McGee was read, on "The field of geology and its promise for the future," and "On some theories of the origin of the gran-

itic rocks," by C. W. Hall. This society will resume the publication of its Bulletins and Transactions, beginning with 1883, and will complete them to the date (probably next fall) of entrance to the new "Library building" constructed by the city of Minneapolis, where it will occupy the entire second floor.

GEOLOGICAL MAP OF EUROPE. Since the last announcement of the additions to the list of subscribers, the following additional names have been received

Cincinnati Society of Nat. Hist.
Parker Collegiate Institute, Brooklyn.
Western Reserve University, Cleveland, O.
School of Mines, Rapid City, Dakota Ter.
S. H. Emmons, Harrison. N. Y.

This leaves but eight copies undisposed of. Those who wish to take advantage of the favorable terms offered for securing the map should not fail to send in their names at once.

MR. TOPLEY, GENERAL SECRETARY of the Committee of organization of the International Geological Congress, in London, desires to call the attention of all societies and individuals to the advantage of subscribing ten shillings to this committee, directed to William Topley, Esq., 28 Jermyn Street, London, for which all the publications distributed to the Congress (some of which will be very valuable) besides the volume of the proceedings, will be sent to the subscribers.

It is probable that much of the valuable literature obtained in this way can be obtained in no other. If its bulk is such that a further trifling sum will be needed to carry it through the mails, the announcement will be made in due time.

Every library and institution of learning should send this subscription, as well as every individual interested in the geological questions of the day.

ARRANGEMENTS ARE BEING MADE for presenting in the GEOLOGIST fitting memoirs of Prof. Wright, late state geologist of Michigan, and of Prof. Worthen of Illinois.

WE REGRET TO RECORD this month the death of Prof. R. D. Irving of Wisconsin, the well-known scientist, and the third state geologist who has died during the year. We shall gladly give space to a memoir in the near future.

DR. M. E. WADSWORTH, principal of the Michigan Mining School at Marquette, has been appointed state geologist of Michigan.

DR. JOSUA LINDAHL of Augustana college, Rock Island, has been chosen to succeed Prof. Worthen as curator and librarian of the Illinois state museum.

THE

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PALÆONTOLOGIC AND STRATIGRAPHIC "PRINCIPLES" OF THE ADVERSARIES OF THE TACONIC.

BY JULES MARCOU.

II.

MR. WALCOTT'S STRATIGRAPHY AND NOMENCLATURE OF THE TACONIC AREA.—I shall briefly notice the different groups of strata called numbers, 1, 2, 3, 4, 5, and 6, by Mr. Walcott. No. 1, or quartzyte series, or granular quartz, is the oldest of the sediments known on the eastern side of the Taconic area. The fauna correlates it with the Taconic of Georgia, but according to Mr. Walcott not so low in position as the fauna of the lower strata of the Georgia slates, an opinion which requires confirmation. No thickness is given. Mr. Walcott disagrees with his associates Messrs. Dana, Hall and Hitchcock as to the age of No. 1.

No. 2 formed of "hydromica slates" on the section of Mr. Walcott, is assumed to represent the Potsdam sandstone. No fossils there. Thickness 2,000 feet. Mr. Walcott is rather obscure, saying, that "to the east of the limestone (of the Taconic Georgia), the Potsdam may be represented in part by either (1) the upper part of the quartzyte No 1; (2) the lower part of the limestone of No. 3 (C. C. T.,) or (3) the hydromica shale between the quartzyte and limestone or No. 2; or by a combination of two or more of these parts." Finally Mr. Walcott regards No. 2 as the Potsdam *off shore* originally deposited as a calcareous or argillaceous mud. Only in the eastern Taconic area, the deposit is as near the shore as that round the Adirondacks, and not at all an "off-shore deposit," as Mr. Walcott wants to make it.

There is no proof whatever that No. 2 is the Potsdam sandstone and its identification by Mr. Walcott is made against all

the rules of stratigraphy, lithology and palæontology and in direct opposition to his statements, that he "takes up the question of the Taconic system in geology, as one that can only be intelligently understood and decided by the application of the principles." [*Loc. cit.* p. 230]. The only fossil of any value, as truly characteristic of the typical Potsdam, the *Conocephalites minutus of Keeseville* has not been found anywhere in the whole original Taconic area notwithstanding its great proximity to Keeseville. As to the two *Lingulepses*, every geologist and palæontologist knows how that genus is unreliable, passing through several zones without any perceptible changes in the species.

The fossils found in Dutchess county, and at some other points, show that lenticular masses of limestone inclosed in the Taconic slates contain primordial fossils, and that they belong very likely to the lower part of the Phillipsburgh and Pointe Lévis group.

Mr. Walcott believes that the only group of strata existing between the Georgia slates and the Calciferous sandstone, is the Potsdam; a theoretical view which suppresses four-fifths of the upper Taconic and of the supra-primordial fauna. We have there the explanation of his constant effort to bring out a Potsdam formation first at Georgia and then in the original Taconic area. It is a misdirected effort. A careful revision and good descriptions of all the fossils existing in the typical Potsdam of the western part of lake Champlain extending from Port Henry, Keeseville, Potsdam and Chateaugay, are much wanted and a great *desideratum*. For the name "Potsdam sandstone" or "Potsdam formation" has been used so freely during the last forty years, that it is almost certain that nine-tenths of what has been referred to it, does not belong to the Potsdam, even with the help of "off-shore deposits." Mr. Walcott disagrees here also with his associates, for the other adversaries of the Taconic have regarded all the strata united under his number 2 as belonging to the Champlain system.

No. 3 or "limestone and marble belt" (Stockbridge limestone) is regarded by Mr. Walcott as the equivalent of the Trenton, Chazy and Calciferous or Calciferous-Chazy-Trenton (C. C. T.) of the Champlain valley. No list of fossils is given; no thickness, referring for the proof of the age of that group, to

the evidences given by Mr. Dana in *Amer. Journ. Sci.*, 1872 to 1887. Only in his *Resume* Mr. Walcott says that his No. 3 "is essentially a repetition of the Lower Silurian (Ordovician) section of the Champlain valley. It differs in lithologic details and in having a less abundant fauna in the Taconic area," (*Loc. cit.* p. 320); an admission of differences which at first seem of no consequence, but which involve the entire question of age and synchronism.

MR. DANA'S PALÆONTOLOGICAL EVIDENCES.—As No. 3 is the strongest point in the controversy on the part of the adversaries of the Taconic, I shall show what are the palæontological proofs given and their value.

The two papers by Mr. Dana, entitled: "A. Wing's discoveries in Vermont," (*Amer. Journ. Sci.*, vol. xiii, p. 332 and p. 405, 1877,) and "Geological age of the Taconic system," (*Quart. Journ. Geol. Soc., London*, vol. xxxviii, p. 397, 1882,) contain all the palæontology of the question. No plates; no description of species; only the names and a few words of explanation, which is much to be regretted, for observers who want to give such a decided view on difficult points, ought to have taken proper care to produce proofs, upon which everyone can form an opinion.

In his paper of 1877, Mr. Dana says, p. 388, that at a marble quarry of West Rutland, two fossils were found, one like *Pleurotomaria staminea*, and a plate of *Pleurocystites tenuiradiatus*, determined by Billings in June, 1871. Mr. Dana did not quote the part of Billings' letter, in which he twice repeats the word *obscure* saying: "Encrinites and *obscure* fossils, *supposed* to be Trenton;" and "numerous *obscurely* preserved forms like *Pleurotomaria staminea*." Nay, more, the quotation given by Mr. Dana is: "I think this collection is Chazy. The cystidean *Pleurocystites tenuiradiatus*, is a never failing guide to the Chazy; at least it is so on the west side of lake Champlain;" when all Billings said was: "I think this collection is Chazy;" the rest of the paragraph has been added by Mr. Dana, and is not from Billings. At other parts of the vicinity of Rutland, encrinal disks, a shell resembling an *Euomphalus* and a *Murchisonia* were found.

The only conclusion to be drawn is that we have at Rutland,

the Phillipsburgh group containing a few forms recalling the second fauna, a sort of precursory center of apparition of the second fauna; and that the Rutland marble belongs to the lower division of the upper Taconic system.

At Sudbury, Wing found *in situ*, in a lenticular mass of limestone inclosed in a "great central belt of slates" a *Trinucleus concentricus*. If the determination is exact, we have here a colony of the second fauna inclosed in the Swanton slates, as at Highgate Springs.

At Eastern Oswell, and Shoreham, Whiting and Cornwall, Wing found: *Stenopora fibrosa*, and *St. petropolitana*, *Receptaculites neptuni*, *Columnaria alveolata*, *Maclurea matutina* and *Mac. sordida*, *Ophileta complanata* and *Oph. campacta*, *Bathyurus saffordi* (very common at Phillipsburgh and at Pointe Lévis), *Bathyurus extans* and *Bathyurus conicus*, *Asaphus canalis* and *Trinucleus concentricus;* in all thirteen species determined, showing a mixture of the second fauna with the primordial fauna represented by three *Bathyuri*. Besides, a certain number of fossils were collected, which are referred to only by generic names, such as *Orthis*, *Orthisina*, *Orthoceras*, *Petraia*, *Holopea*, *Rhynchonella*, *Strophomena* and encrinal disks, showing also a mixture of second fauna forms with primordial forms. The *Bathyurus* is very numerous and also the *Maclurea*. I saw those two genera at Shoreham in 1862, and I referred the strata there as belonging to the Phillipsburgh and Pointe Lévis group of the upper Taconic. At North Cornwall, Middleburg and Weybridge, the fossils recorded by Wing are: *Bathyurus saffordi* and *Bathyurus angelini*, *Asaphus canalis* and *Retepora incepta*, four species in all, with a certain number of undetermined species belonging to *Maclurea*, *Murchisonia*, *Orthoceras*, *Rhynchonella*, *Orthis*, *Leperditia* and encrinal stems. A fauna of the Phillipsburgh and Pointe Lévis group.

At a few other localities, *Orthoceras*, *Maclurea*, *Murchisonia*, *Rhynchonella*, *Orthis*, and *Ophileta* are mentioned by him.

In all we have only eleven species of the second fauna, representing corals, gasteropods and a single trilobite, *Trinucleus concentricus*, mixed with four species of very common and characteristic supra-primordial trilobites, *Bathyuri;* and we have not a single Lamellibranch, nor a fragment of any of the

large and so numerous trilobites of the second fauna, such as *Ceraurus*, and more especially *Isotelus gigas*, fragments of which can be picked up by the hundred and thousand at Chazy, Plattsburg, isle La Motte, Grand isle and South Hero, in the middle of the very narrow lake Champlain, at a distance of less than a cannon shot.

Mr. Dana in his paper "on the geological age of the Taconic system" of 1882, repeats on pp. 401 and 402 the same names of fossils, adding only on p. 405, five brachiopods [*Orthis lynx*, *O. pectinella*, *Rhynchonella capax*, *Leptæna sericea* and *Strophomena alternata*), a coral *Petraia corniculum* and a trilobite *Illænus crassicauda*. Besides he quotes, *Orthoceras primigenium*, *Maclurea magna* and finally *Orthis testudinaria* found by Messrs Dwight and Nelson Dale in Dutchess county.

Adding all the species identified, and accepting them as well determined, a fact which for several of them admits of doubt, we have only twenty-one species of the second fauna, mixed in the four *Bathyuri* of the first fauna, and very likely some other primordial fossils not yet recorded, scattered from Middlebury to Poughkeepsie, contained in lenticular masses or belts of limestone — never in the slates — showing only sporadic apparitions of less than six per cent of the Calciferous-Chazy-Trenton fauna. It is the old classification revived of the Quebec group of Logan, to which Messrs. Dana and Walcott have added the Trenton — Logan having synchronized his Quebec only with the Calciferous and Chazy — a rather difficult task round Quebec city and at Pointe Larabée where the Trenton lies in discordance of stratification over the Taconic Swanton slates.

We have here all the palæontological proofs of Mr. Dana, accepted by Mr. Walcott as conclusive of the identity of three or four thousand feet of the Phillipsburgh and Pointe Lévis group, with the one thousand feet of the typical Calciferous-Chazy-Trenton of Chazy in the western part of lake Champlain.

This is one of the "principles" used by the adversaries of the Taconic system.

Mr. Walcott did not try to recognize, as Mr. Dana and others did, in his No. 3, the Calciferous, Chazy, Birdseye, Black River and Trenton, at Fort Cassin, Snake mountain, Shoreham, Rutland, Wappinger etc., nor did he signalize anywhere the Quebec

group of Logan. He thought that the dozen, or at most twenty odd identified species of the Champlain system, were not enough to sustain such divisions and sure recognition of groups, and he preferred to put all pell-mell in a single big lump or great heap, which he called Calciferous-Chazy-Trenton, an "off-shore deposit" according to his phraseology. He has however made a single exception for Whitehall, where he gives a section in which he signalizes the Calciferous, the so-called Chazy with a band of shales between, then the so-called Trenton with a second band of shales, and above his so-called Hudson group (no Utica slate); "the strata of the entire section are conformable; and the limestones were identified by contained fossils" (*Loc. cit.* p. 318). But no name of a single fossil is given, and Mr. Walcott does not state whether the shales are fossilferous, or whether he found fossils in his so-called Hudson group—a singular neglect on his part, for Messrs. Dana and Wing have not described Whitehall.

Resume—The fact that such an expert in finding fossils and in palæontologic work as Mr. Walcott is, has hesitated to determine the age of the groups of strata contained in his Calciferous-Chazy-Trenton, twice as thick as the Champlain system, and lithologically different, shows plainly that it was too much for him, even with the help of his overlapping fault and other faults so easily and freely used since Logan discovered them in his Montreal office on the new year's eve of 1861. Mr. Walcott has failed to show palæontological, stratigraphical and lithological evidences that his No. 3 is the homotaxis of the Calciferous, Chazy, Birdseye, Black River and Trenton formations, of the same region, which are so beautifully developed and typical close by, in the same basin at Trenton Falls, Chazy, and many other localities of the state of New York. The few fossils, all ill preserved, not one described, and also not represented by good figures, are all of doubtful value, not only for their identification, which is far from proved, but also as characteristic fossil species (*Leitmuscheln* in German).

THE TACONIC SLATES ARE NOT IDENTIFIED WITH THE UTICA SLATES OF DUDLEY OBSERVATORY.—The No 4 referred by Mr. Walcott to the Hudson River group (Lorraine shales,) is given without its thickness, and without palæonto-

logical proofs, except that he has called *Diplograptus pristis* the *Graptolipthus simplex* of Emmons. He declares that the majority of the species of graptolites described by Dr. Emmons from his Taconic system, are now known to occur also in the Hudson group, in the valley of the Hudson and elsewhere, saying: "that proves that Dr. Emmons had not a clear idea of the position of the shales of the Hudson river valley that contain the graptolites described by Prof. Hall, nor of the shales at Pointe-Lévis carrying the graptolitic fauna."

Previously in the palæontological part, I have presented some objections against Mr. Walcott's opinions on the graptolites of the Taconic system, and now I shall add a few stratigraphic remarks, in order to show who has "a clear idea of the position of the shales" containing the graptolites.

Mr. Walcott lays great stress (in order to remove the "red slates" containing graptolites from the Taconic) on the discovery of Mr. C. E. Beecher, north of Dudley observatory on the line of the New York Central railroad; saying: "At Albany N. Y., however, the graptolite beds contain a characteristic Trenton-Hudson fauna. This removes a considerable portion of the Upper Taconic strata from the Taconic system" (*Loc. cit.* p. 322). Mr. Walcott does not give any approximate thickness of what he calls "a considerable portion of the Upper Taconic." As presented in Mr. Walcott's footnote p. 322, it seems a necessary conclusion that the graptolite beds of the Taconic area belong to the Utica slate of the Dudley observatory of Albany.

ANOTHER "PETIT-CŒUR CASE.—Now we have at the Dudley observatory an abnormal association of fossils — three species of graptolites (*Climacograptus bicornis*, *Dicranograptus ramosus* and *Diplograptus mucronatus*) found by Mr. Walcott in the Taconic slates of Washington and Rensselaer counties, mixed with Lamellibranchia, sixteen species; Brachiopoda, five species; Pteropoda, two species; Gasteropoda, three species; Cephalopoda, two species; Annelid, one species; Crustacea one species, and Trilobites, two species — which have never been found before nor since anywhere else, and more especially in the whole original Taconia area, in Canada and in the original Utica-Lorraine area of central and northern New York.

Mr. Walcott has neglected to report with accuracy the state

ments of Mr. Beecher's paper; a neglect which invalidates and annuls his whole conclusion given with such emphasis. Mr. Beecher says: "The beds carrying those fossils (twenty-three Utica species and three Swanton and Citadelle Hill of Quebec species) are *nearly vertical.*" (Thirty-sixth Ann. Rep. N. Y. State Mus. Nat. Hist. p. 78, Albany, 1884.) In other words, the locality of the Dudley observatory is a case of abnormal stratigraphy, and cannot be used against the regular positions of the Utica slates and the Swanton slates (Taconic slates). We have here another example of the celebrated case of Petit-Cœur in Tarentaise (Savoy Alps), only less complicated; for at Petit-Cœur we have two horizons of a Carboniferous flora inclosed twice in roofing slates containing Liasic Belemnites, which Elie de Beaumont regarded, as a very strong point towards proving that a Carboniferous flora inclosed was contemporary and of the age of the Jurassic epoch.

At Dudley observatory a palæontologist [Mr. Walcott] "hammer in hand" and who is accustomed to "collect fossils at all places where they could be found," refers, without hesitation and in accord with the application of the principles "intelligently understood" of the adversaries of the Taconic system, the graptolitic fauna of the Swanton slates and Citadel Hill of Quebec, of the third graptolitic zone of the Upper Taconic, to the age of the Utica slate, and indeed as contemporary with it, containing a beautiful and characteristic upper Champlain fauna, such as *Avicula trentonensis*, *Cleidophorus planulatus*, *Ambonychia undata*, *Tellinomya dubia* and *T. levata*, *Zygospira modesta*, *Lyrodesma poststriatum*, *Triarthrus beckii*, *Endoceras proteiforme*, etc. Only at Dudley observatory no repetition of the Taconic graptolites have been recorded, and we have a great deal more simple stratigraphical accidents. A small piece or parcel of Swanton slates—recognized close by at Kenwood—has slid into the Utica slates, during the very strong pressure of the Utica slates against the wall of the Taconic system formed by the Swanton slates. The break and upheaval of the Champlain system came long after the break of the Taconic strata, which formed an elevated dry land (terra firma) all over the original Taconic area, during the deposition of all the strata composing the Champlain system. That sort of stratigraphic

accident is very common in the Jura and in the Alps. I have quoted only the "*anomalie stratigraphique de Petit-Cœur en Tarentaise*," because Mr. Lory has shown that in Europe, it was a stratigraphist, Elie de Beaumont, backed by other stratigraphists, Angelo Sismonda, Sipion Gras, etc., who wanted to refer a Carboniferous flora to the Jurassic system; while here in America, it is a palæontologist, Mr. Walcott, backed by other palæontologists, Messrs. Beecher, Hall, Ford, etc., who want to refer an Upper Taconic group of graptolites to the Utica slates, a transfer over the whole Champlain system of the third graptolite zone of the Taconic system. Something analogous and a repetition of the error made by Mr. Hall for the primordial trilobites of Georgia, who transferred them from the middle Taconic to and even above the Lorraine shales.

After this explanation of the mistake made by Mr. Walcott, in regard to a "considerable portion of the upper Taconic slates" of Emmons, the age which he has assigned to his so-called Calciferous-Chazy-Trenton, which according to his description, section and geological map lay inclosed between two primordial faunas (the Quartzite and the third graptolitic zone) is untenable and disposed of. Nothing can extricate Mr. Walcott's No. 3 from its stratigraphical position, and all the overlapping faults, or any other faults, so freely used by the adversaries of the Taconic, cannot help them out of this dilemma.

One word more and I have finished with those Swanton graptolitic slates of the Hudson river valley, taken constantly by the adversaries of Dr. Emmons as belonging to the Hudson group and placed above or with the Utica slates. Mr. Walcott visited, in company with Mr. Ford, a place in Schodack Landing N. Y., described in 1885 by the last named observer in *Amer. Jour. Sci.*, vol. XIX, p. 16, under the title: "Observations upon the Great Fault in the vicinity of Schodack Landing, Rensselaer county, N. Y." In his visit Mr. Walcott "saw the *hade* of the fault, the slikensides on the opposing surfaces, and broke out graptolites (no specific names) from the Hudson shale, beneath, and within six inches of the fault line" (*Loc. cit.* p. 319). If we trust the section published by Mr. Ford at p. 19 of his paper, there is no discordance of stratification whatever between what he calls Lorraine shales (Hudson group of

Walcott) and the Lower Potsdam (Middle Cambrian or Georgia formation of Walcott), and the fault is "purely hypothetical." On p. 18, another section is figured, with the admission that "the precise position of the fault (the Great Fault in Rensselaer county) is somewhat uncertain;" and to increase the incertitude Mr. Ford put it in the bed of a creek—an invisible fault. Finally the geological sketch map at p. 17, shows a perfect concordance of his so-called Lorraine shales and so-called Lower Potsdam group. A simple bending or slight curl of the whole mass of the Georgia slates and Phillipsburgh and Pointe-Lévis group has been taken by Messrs. Ford and Walcott as a great fault.

THE GEORGIA FORMATION.—No. 5 referred to the Georgia slates or Middle division of what Mr. Walcott calls Cambrian, is rather confused in the text, in the geological map and in the section. On the geological map the Georgia formation is composed of three groups, two with the same number 1, two different colors and a geographical distribution completely distinct. On the section we have only a single number 1, which refers to the Quartzites, and the No. 1 [red sandrock] is not represented. Mr. Walcott after carrying on the map the red sandrock as far as the latitude of Shoreham and parallel there to his No. 5, makes it disappear under his Calciferous-Chazy-Trenton, and even under his Hudson group.

However leaving Mr. Walcott to explain his numerous contradictions and confusions with regard to the equivalency of his No. 1 being "the sandy deposit of the shore line" and his No. 5 the "off-shore" accumulation of finer sediment, I shall say, that his No 5 is formed of 14,000 feet or more of strata, containing Taconic fossils, at over 100 localities within the typical Taconic area—among them the original locality with special fossils (the primordial fauna) described and figured by Dr. Emmons, as far back as 1844. As to his saying that "it was a *fortunate happening* that the upper Taconic fossils proved to be of pre-Potsdam age and not a scientific induction based on on accurate observation and comparisons;" and that Mr. Barrande was misled into crediting him (Emmons) with a discovery that was based on errors of field observations, it is sufficient for me to have quoted those remarks. No answer is

required, it being a question of dates, publications, and discoveries made by Emmons and Barrande and denied by Mr. Walcott. Between the honesty of the discoverers of the Taconic system, the primordial fauna, and the exact stratigraphical position of the primordial fauna, and the partisan and unpatriotic action of an observer who is contradicting each year what he has said the year before, the choice is not doubtful.

As to the allusion of Mr. Walcott to Mr. Barrande's visit to England in 1850 (not 1851 Walcott) and his determination of the age of the primordial fauna found in the typical Cambrian area of Wales [*Loc. cit.* p. 327], referring to Barrande's paper of 1851 [*Bulletin Soc. geol. France*, tome viii, pp. 207-212], it proves how little Mr. Walcott is acquainted with what Barrande did in England, during his visit in November and December, 1850, and how he misunderstood Barrande's paper. In visiting the Museum of Practical Geology, Jermyn street, in London, in company with De la Béche, Edward Forbes, Ramsay, Jukes and Salter, M. Barrande was struck by a specimen of a fragment of a large trilobite, *without any sort of label.* He recognized at once a *Paradoxides*, and said, "You must have in England the primordial fauna, if that specimen is English." No one knew where the specimen came from; only they were all certain that it was found in the British islands. And at the same time all protested that the primordial fauna of Bohemia did not exist in any part of the whole united kingdom. However, Forbes and Salter, the two palæontologists, were both ready to admit that the primordial fauna must exist somewhere in Wales, notwithstanding the denegation of the stratigraphists; and Salter from that day began his researches for *Paradoxides* in Wales. But it was not until 1862 that he was rewarded in his persistent researches by the discovery at St. David, *in situ* of "a gigantic trilobite long looked for in Britain," described by him in February, 1863, under the name of *Paradoxides Davidis* [*Quart. Journ. Geol. Soc., London*, vol. xix, p. 275 and vol. xx, p. 233], and regarded wrongly as belonging to the "Lingula flags of Wales," as it is far too high up, by several thousand feet, in the true series of the lower palæozoic strata of British isles.

I will now give M. Barrande's opinions in favor of the just

claims of Dr. Emmons, and of the right of American geology to be represented in the general classification and nomenclature of the world.

"At its origin, that is to say from 1838 to 1842, his [Emmons] Taconic system was presented as founded on petrographic and stratigraphic observations, and constituted simply the *sedimentary base*, according to the American expression. It was still without any characteristic fauna. But in 1844, Dr. Emmons having discovered in this formation fossils before unknown, his Taconic system for him represented the *palæozoic base*."

"This expression, used on the other side of the Atlantic, is evidently equivalent to that of 'primordial fauna,' which I have applied to the trilobitic group, the oldest of Bohemia, defined for the first time in my *Notice preliminaire*, in 1846. It is known that the *Lingula* (only, no trilobites were found then,) which characterize the corresponding horizon of Lingula flags in Wales, thát is, in the Cambrian region of England, were only discovered by Mr. Davis in 1845 [*Siluria* 2d ed., p. 43, 1859]."

"In comparing these dates it is clear that Dr. Emmons had *first* announced the existence of a fauna anterior to that which had been established in the "Silurian system" as characterizing the "Lower Silurian' division, and which I have named *second fauna. It is then just to recognize this priority, and I think it all the more fitting to state it at this time, that it has not been claimed to this day*."[1]

At the end of his paper Mr. Walcott has recourse to the authoritative "principles," so often and always so unfortunately used by his associates Messrs. Hall, Dana, Logan, etc.; he says: —USE OF THE NAME CAMBRIAN.—"There is no necessity for reviewing the Silurian-Cambrian controversy. All the facts, as understood by many writers, are accessible to the student of English geologic literature. It is my opinion that the name Cambrian should be used for the system of strata characterized by the first fauna." Certainly a very easy way of answering my paper, "*on the use of the name Taconic*," Salem, September, 1887.

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[1] "Documens anciens et nouveaux sur la faune primordiale et le systeme Taconique en Amerique." (*Bulletin Soc. Geol. France*, tome xviii, p. 225, 1861.)

As to his use of the names Lower Silurian and Ordovician instead of Champlain system, it is another example of his complete disregard for the right of priority of American geological names. Never has such a surrender of just claims of discoveries and of the right of priority into the hands of another nation been made. It will not be forgotten by the actual and future generations of American geologists.

THE SECTIONS AND GEOLOGICAL MAPS OF THE TACONIC AREA.—Among the "principles" put forward by Mr. Walcott, at the beginning of his paper in order to have "the question of the Taconic system intelligently understood," he makes the statement that "different sections of strata in the same province may be compared with one another when the continuity is broken." A "principle" used constantly by every practical geologist everywhere, as can be seen exemplified in almost all stratigraphical papers issued during the last forty years. It was to be expected that Mr. Walcott would follow the "principle," but we searched his paper in vain; there is not a single section given with the details required for a comparison. Trenton falls and Utica being in the "same province" and the same basin as the Taconic area, as well as the Champlain sections at Chazy, isle La Motte, Grand isle, South Hero, one would have expected to find good and detailed sections [giving the thickness, the lithology, the exact position of fossils, their names, their abundance or rarity, their affinities and associations, etc.,] of those localities in Mr. Walcott's paper, as well as detailed sections of the Taconic area, in order to allow every geologist to compare and judge for himself. But instead we have only drawn on the upper part of the map, a general section across the Taconic area, without any sort of details, showing only *a general outline* of the ground, with the amount of invisible faults necessary to account for the stratigraphic classification and nomenclature used.

The geological map of Mr. Walcott instead of being an improvement over the old map of Dr. Emmons of 1844, is a backward move, which takes out from the Taconic area half of the surface occupied by the Taconic system, referring it wrongly to the Champlain system.

After forty-four years of discussions and researches, the adversaries of the Taconic system have not been able to publish

a general map of the original Taconic area, nearly as exact and correct as Dr. Emmons' suppressed geological map of the agricultural report of New York. The general and local maps published by Logan and Hall, the two Hitchcocks, Dana, Wing, etc,, are absolutely valueless so far as classification and nomenclature are concerned. We see now, why the opponents of the Taconic system have such an interest in the suppression of Emmons' map, for all together to this day they have been unable to give anything approaching its correctness and real value. The eastern boundary from the Canada line, to the state of New Jersey is good, and the western boundary along the eastern shores of the Hudson river, all along the Hudson valley and lake Champlain, is exact in the main, and superior to any given since.

In a foot-note (*Loc. cit.* p. 309) Mr. Walcott says that he has "reason to state that 3,000 copies were originally delivered to the Secretary of State, of the State of New York, by the printers, and I think that copies can still be obtained from the said secretary's office, despite the published statement that the edition was stolen or destroyed." Such statement seems to mean that if Dr. Emmons had applied to the Secretary's office the 3,000 copies wanted for distribution with his final volume of the "Agriculture of New York," would have been delivered to him. The Secretary of State was not a geologist, and had no personal interest in keeping from its author an important map of a great report, made and paid for by the State; and its disappearance and suppression during all the life of Dr. Emmons, and even during fifteen years after his death, must have a reason. Every unprejudiced person will lay the blame at the door of those whose interest it was to suppress the Taconic system and all public marks of its existence.

"The Geological sketch map of the Taconic range," published by Mr. Dana in 1882 *Quart. Jour. Geol. Soc. London*, vol. XXXVIII, p. 408) does not contain a single spot of strata referred to its true stratigraphical position. The Primordial extends only from Burlington to opposite the entrance of lake George, the *whole of the original Taconic area being entirely devoid of primordial strata.* Mr. Walcott's geological map is not so sweeping; half of Washington and Rensselaer counties are

covered by Primordial; but all the other half referred to the Champlain system is erroneous, except Larabee Point (lake Champlain,) and a few spots in the western part of Washington county.

The part of the map colored from field-work made by Mr. Walcott in 1883—84, in Franklin county, is not only at variance with what exists there but even with his own section published in 1886 (*Bulletin U. S., Geol. Sur., No. 30, p. 16.* At his Parker's section, Georgia, he has placed a large band of "Hudson River formation" on the shore of lake Champlain; on the map the Hudson is replaced by his middle part of Georgia, called limestone [red sandrock]. The shales of his No 2, which he regards as an "off-shore Potsdam sandstone deposit," are not distinguished on the map, being merged with the Georgia formation.

Résumé — All Mr. Walcott's classification rests on the following points.

A. The quartzyte must be younger than the middle and Lower Georgia formation, and he regards it as the upper part of that formation without any stratigraphic proofs, only on the plea of a very few fossils which he interprets according to his present palæontological tendency, and limited knowledge.

B. The Potsdam formation being placed by him directly above the Georgia, in order to suppress the six thousand feet of the Phillipsburgh and Pointe Levis group, and the Swanton and Citadelle Hill of Quebec slates, Mr. Walcott makes extra efforts to find it somewhere in direct contact and superposition over the Georgia. Not being able to find the true Potsdam sandstone, which exists close by—only a couple of miles off, on the edge of the Adirondack mountains, he has recourse to a "belt of shales" which he assumes to represent the Potsdam sandstone, as an "off-shore deposit" contemporary with the true Potsdam. But even that assumption, contrary to all the characters of stratigraphy, lithology and palæontology, that belt of shales is not sufficient; and in Dutchess county he has recourse to a limestone. However it is not yet enough, for to the east of this supposed Potsdam limestone, he says that the Potsdam "may be represented in part by either [1] the upper part of the Quartzyte No. 1, [2] the lower part of the limestone No. 3, or [3]

the hydromica shale between the quartzyte and limestone, or No 2, or by a combination of two or more of the these parts" [*Loc. cit.* p. 241]. It is difficult to imagine something more confused, and more difficult to be "intelligently understood" and so far from "an accurate definition."

The Potsdam sandstone is wanted there, for without it all the structure of his classification cannot stand, and Mr. Walcott must have it, even if he is obliged to have recourse to "subsequent faulting of the strata," to replace it in "its *usual position*, between the Georgia and the Calciferous formations." By *usual position* Mr. Walcott means only the position which he has chosen to give theoretically, without a single proof to sustain it.

C. The Stockbridge limestones and other belts and lenticular masses of marble inclosed in slates in the Taconic area, must be Calciferous-Chazy-Trenton limestone, notwithstanding the stratigraphy, the lithology and even an abnormal and special palæontology, for only a dozen of fossils of the second fauna, lost among the two hundred and fifty or the three hundred species of the supra-primordial fauna, cannot carry to Trenton Falls, Chazy village and Montmorency falls, the three thousand feet of strata of the Phillipsburgh and Pointe Lévis group.

D. The roofing slates and "Black slates" of Emmons, must belong to the Hudson-Utica group, because four graptolites require it, according to an erroneous interpretation of the unique locality of Dudley observatory, and the no less erroneous determination made by Mr. Hall of one graptolite against the good description and figure of Dr. Emmons.

Without those four points [A. B. C. D.],or even if only one of them is proved untenable, all the classification given with such assurance by Mr. Walcott cannot be accepted; and I think I have given in the preceding pages enough reasons to reject them all.

VARIA.—A few more remarks before concluding. Mr. Walcott's group No. 6, composed of red, black and green slates "faulted between the two parts of No. 5," containing graptolites [no names are given] is referred to his Hudson group. "Its distribution and relation to the other groups is shown on the map and in the section." On the map there is no trace of

No. 6 and no explanation whatever. On the section, instead of being under No. 6, it is marked No. 4: and the No. 6 of the section is the *gneiss* or pre-Cambrian according to Mr. Walcott's phraseology; another needless confusion.

Mr. Walcott says: "Dr. Emmons' errors are nearly all traceable to his trust in the lithologic characters;" and Mr. C. H. Hitchcock says: "His palæontological arguments were better than the stratigraphical ones." A disagreement of opinion between two of the adversaries of Emmons, who have made, both of them, errors far superior to any ever made by Dr. Emmons; for Emmons' errors are simply errors of detail in a difficult study, and at the beginning of it—errors of a pioneer only in the opening of a new and splendid road; while Messrs. Walcott and Hitchcock's errors affect the whole system, and besides are made forty-four years after Emmons' discoveries and splendid works, twenty-seven years after Barrande's letters to Marcou, and twenty-five years after Marcou's "Comparative tabular sections" of the Taconic with all its groups, for the northwest part of Vermont and the vicinity of Quebec.

As to what Mr. Walcott says, "that there was no valid stratigraphical evidence of the pre-Potsdam age of the Black slates," where Dr. Emmons got the two species of trilobites, first found by Dr. Fitch near Bald mountain in 1843, it is simply an assumption on his part that he is right in his reference of the Black slates, or any part of them, to the Utica slates, when on the contrary all those slates belong to the Upper Taconic. Mr. Walcott in his paper reproaches Dr. Emmons with committing errors constantly, when it is he who is erroneous, very confused and inexact.

But furthermore, Mr. Walcott says: "Dr. Emmons was not a collector of fossils." Nothing is more unjust and untrue. Dr. Emmons found more fossils than anybody else among his contemporaries; for then it was not so easy as it is for Mr. Walcott with dynamite explosives, fresh cuts for railroads in all directions, new and numerous quarries, to collect fossils where Emmons did not find any. It is no small compliment for Emmons to say that even his *American geology*, an elementary book, contains plates, figures and descriptions of fossils which very lately have been copied *verbatim* and reproduced by the

United States Geological Survey in one of its monographs, No. VI [Fontaine's *Older Mesozoic flora of Virginia*, 1883]. In the same elementary work are also the primordial fossils, reproduced in Paris by Barrande, in 1861; and in it is found the first figure and description of the oldest mammal found on earth, the *Dromatherium sylvestre.*

Mr. Walcott has attacked Dr. Emmons on every possible point: palæontology, stratigraphy, lithology, classification, use of the name Taconic, right of priority, as a collector of fossils, and even as to the disappearance of his Geological map from the first volume of the *Agriculture of New York.* It is difficult to think of something more unjust, entirely out of date—for it is more than a quarter of a century since Dr. Emmons died. His discoveries and observations have stood more assaults and a more bitter opposition than all the other discoveries put together of the whole stratigraphic series. I thought that the time "had arrived for more just and less passionate discussion," but the paper of Mr. Walcott has sadly disappointed me. However, I shall not abandon the field, notwithstanding my age and infirmities; and I shall continue to show who is in error, and who is to be blamed. It is a duty from which I shall not shrink, even if the adversaries of the Taconic system are legion.

Conclusions.—The Taconic system is founded on stratigraphy, palæontology and lithology. The errors of its adversaries have been proved again and again during the last forty-four years; and what I have said in this paper answers all the new criticism and strictures lately launched. The six conclusions presented by Mr. Walcott on pp. 394 and 395 of his paper do not reflect credit on him; and not only I shall not answer them, but I shall not even quote them, for they are neither fair, correct, nor patriotic.

For a special purpose easily understood Mr. Walcott repeats twice that I did not make direct researches in the original Taconic area. It is true, I never made regular observations there; but I have crossed it, in several directions from east to west and *vice versa*, and from south to north; and from my practical knowledge of the geology from Shoreham and Middlebury upward, as far as Pointe Lévis and Montmorency Falls, I have not the smallest hesitation in saying, after an attentive study of Dr. Emmons'

publication and of Mr. Walcott's papers, that in the Taconic area, there is not a single strata of the Champlain [Lower Silurian] rocks. All the deposits without the smallest exception in Berkshire, Rensselaer, Bennington, Rutland, Chittenden and Franklin counties belong to the Taconic Series. On the extreme western limit of Washington and Addison counties, close by the great massive of the Adirondack, we have a very small area covered by the Champlain system. The city of Albany and the very spot on which is built the State Museum of Natural History, lie on the upper Taconic division of the Swanton slates, and I am convinced from my numerous observations in Vermont, Canada and New York, that the adversaries of the Taconic series, have constantly erred from the begining in 1842 until now; and that if their errors in 1842, were somewhat excusable, they have not been excusable since 1844, after Dr. Emmons' publication of his "Taconic system" containing a special fauna, the greatest, most important and difficult discovery in American geology. The continuance of the opposition to this day, due mainly to Messrs. Hall, Dana and Walcott, show an absence of geological "principles" almost unexplainable.

It is not the first time that I have corrected a very great and grave error in stratigraphic geology; for in 1859, without going to Russia—where I never was to this day—I have proved in "Dyas et Trias" [*Archives des sciences de la Bibliotheque de Geneve*, Mai et Juin) that the great geological map published by Murchison, de Verneuil et de Keyserling was wrong, in covering vast areas of that empire with the Dyas [Permian]. According to those three learned explorers of Russia, the Trias was almost entirely absent, being reduced on this map, to a small spot not larger than a pin head of Muschelkalk at Mount Bogdo. In my paper I proved that the Permian of Murchison contained the whole Trias, and that two thirds of the surface colored as Permian [Dyas] belonged really to the Triassic system, After a sharp oppositon on the part of Murchison and his partisans my opinion and classification have been entirely accepted, and now all the general geological maps of Russia show, instead of a single spot of Trias, immense surfaces covered by it, as large as twice the united Kingdom of England and

Ireland, and with it a corresponding reduction of the Dyas to an area reduced by two thirds.

In North America it will be the same; after a complete annihilation and suppression of the Taconic system, by its combined adversaries, we shall have vast surfaces of the continent covered entirely by the series of the strata containing the infra-primordial, the primordial, and the supra-primordial faunas.

In my paper, "The Taconic of Georgia and the Report on the Geology of Vermont," Boston, 1888, I hailed "with joy the arrival of new observers, better fitted and armed than I was, sure that now the truth will not be kept much longer in the background." I said also that "the U. S. Geological Survey has a splendid field of operation." I am far from regretting to have welcomed the advent of the new researches and conclusions of Mr. Walcott, although Mr. Walcott has withdrawn subsequently, his communication to the National Academy of Science, of the 22nd of April, 1887, his letter to professor N. H. Winchell, dated June 8th, 1887, and retracted all his views and opinions, unasked for and freely expressed by him in his visit to me in the early spring of 1887. His paper, *The Taconic system of Emmons, and the use of the name Taconic in geologic nomenclature*, is an unjust and passionate contribution to the Taconic question; and if its appearance has disappointed me, in regard to "more just and less passionate discussion," I hope it will serve to awaken the interest of American geologists, and that more of them will be induced by it to go to the Taconic region and see for themselves.

The United States Geological Survey has assumed the duty of representing, to a certain degree, the majority of opinions of observers on American geology. It cannot now leave the Taconic system under such passionate and unpatriotic attacks. Its duty is clearly indicated. A thorough survey, as detailed as the one made of the vicinity of Leadville, Colorado, should be undertaken at once for the whole Taconic area, from the Tappan sea to the Canada boundary line at Phillipsburgh; and the deposits should be followed by a mutual consent and agreement with the Geological Survey of Canada, all through Canada to Gaspé, and even the western part of Newfoundland. A most minute and thorough comparison must be made also of those

deposits with the Champlain system of the typical area, and nothing left to speculation, arbitrary or hasty conclusions.

The accompanying tabular view gives at a glance the classification and nomenclature of the Taconic system as it is viewed by its partisans and its adversaries.

The errors of the adversaries of the Taconic system have been all the time on the side of diminishing the age of the strata, making them always younger than they are. There is not a single example of their having tried to make a group too old, and never any one of them has said, "such division is of such an age *or older*;" no, they say always, "such a division is of such an age *or younger*;" and in their desire to restore to youth the oldest American strata they have gone on so far as to make them get up half the ladder of the stratigraphical scale. The last memoir of Mr. Walcott is an effort in the same direction; and all his argumentation tends to prove that what he calls Nos. 1, 2, 3, 4 and 6 are all younger than they really are; the only difference between him and his associates is that he accepts the stratigraphical position of his No. 5, arrived

TABULAR VIEW OF THE TACONIC SYSTEM.

Emmons. 1842-55. — *Taconic.*	*Hall, Mather, Logan, Rogers, Hitchcock. 1843-60.* — *Suppression of the Taconic.*	*Logan. 1861.* — *Champlain or Lower Silurian.*	*Dana. 1872-83.* — *Lower Silurian and younger.*	*Walcott. 1888.* — *Upper part of the Middle Cambrian and all the Ordovician.*	*Marcou. 1888.* — *Taconic.*
a. Black slate.	a. Hudson Riv. group or a group above.	a. Lower Potsdam.	a. Hudson Riv. group.	a. Cambrian.	a. Georgia slates (in part)—Primordial fauna.
b. Taconic slate.	b. Utica slate.	b. Utica slates.	b. Utica slate.	b. Mostly Hudson slate.	b. Swanton slates and Citadel Hill of Quebec—Supra-primordial fauna with colonies.
c. Magnesian slate.	c. d. e. Champlain, Upper Silurian, Devonian and Carboniferous united in one metamorphos'd mass.	c. d. e. Trenton and Quebec group, or Calciferous-Chazy-Trenton.	c. d. Lower Silurian, or Calcif-Chazy-Trenton.	c. Hudson slate.	c. Georgia slates (in part)—Primordial fauna with colonies.
d. Stockbridge limestone and Sparry limestone.				d. Lower Silurian limestone.	d. Phillipsburg and Pointe Levis —Supra-prim'l f'na, colonies.
e. Granular quartz.			e. Later Lower Silurian or younger.	e. Cambrian.	e. St. Albans, or lower part of the Middle Tac.—Prim'l fauna.

at years ago by Emmons, Barrande and Marcou. Only in regard to Emmons he pretends that "it was a *fortunate happening;*" as to Barrande he was, according to Walcott, misled in crediting Dr. Emmons; and as to Marcou, Mr. Walcott passes silently over him.

Here is a tabular view showing the opinions and classifications of Messrs. Walcott and Marcou in the Taconic area extending from Tappan sea to Montmorency Falls.

MR. WALCOTT.

Nos. 4 and 6—Hudson No. 3—Trenton-Chazy-Calciferous	Lower Silurian, or Ordovician system.
Lower Calciferous No. 2—Potsdam, "off shore deposits"	Upper Cambrian.
Nos. 5 and 1—Georgia and "granular quartz" formations of Vermont	Upper part of the Middle Cambrian.

MR. MARCOU.

Lorraine shales Utica slates Trenton limestone Chazy limestone Calciferous sandstone		Champlain or Cambrian system.
Potsdam sandstone	Upper Potsdam of Saratoga Lower Potsdam of Keeseville	Upper Taconic system.
Swanton slates and shales of Citadel Hill, Quebec. The Nos. 6 and 4 of Mr. Walcott		Upper Taconic system.
Phillipsburgh and Pointe Levis formation. The No. 3 of Mr. Walcott, and also his No. 2 "off-shore deposits"		Upper Taconic system.
Georgia formation	Georgia slates. The No. 5 of Mr. Walcott St. Albans or granular quartz. The No. 1 of Mr. Walcott	Upper part of the Middle Taconic system.

SOME REMARKS ON THE PRESENT STATE OF OUR KNOWLEDGE OF THE NORTH AMERICAN EASTERN TERTIARY.

BY OTTO MEYER, PH. D.

The marine Tertiary of the eastern part of the United States is extensively developed in all the states along the coast from New York to Texas. Along the Mississippi valley it penetrates deeply into the continent, reaching into the states of Arkansas, Tennessee and Kentucky. It thus covers a large area and is altogether one of the most extended tracts of marine Tertiary on the earth, in comparison with which the famous

Tertiary territories, like the Paris, London or Mayence basins, are insignificant spots. Owing to the small amount of work done in this large field this formation is comparatively unknown. While the states whose territory is constituted by older formations are mostly well studied and mapped. The Tertiary states, if this expression may be used here, stand generally in these respects behind some western territories.

The eastern Tertiary may be divided into two groups; one, the Atlantic group, comprising the Atlantic states proper from New Jersey to Florida, the other, the Gulf group, including the states from Alabama to Texas. In the first group the younger Tertiary formations are extensively developed, while the marine beds of the Gulf group are Old-Tertiary. We may consider first this Gulf group.

THE GULF GROUP—Our knowledge of the palæontological condition of the Gulf group is unsatisfactory. There are indeed several hundreds of species of marine invertebrates known from it, in the description of which quite a number of authors have participated—S. G. Morton, T. A. Conrad, I. Lea, H. C. Lea, W. M. Gabb, R. P. Whitfield, A. Heilprin, O. Meyer, T. H. Aldrich, D. W. Langdon, H. B. Geinitz. Yet there is no doubt that many hundreds more occur in it, which are still unknown. Almost every new locality furnishes new species, and the most thoroughly explored places yield new forms, when again examined. It is, however, less the quantity of known palæontological material, which is unsatisfactory, than the quality, and the writer, after having examined nearly all the existing type-specimens of the Old-Tertiary may be pardoned, when he calls this part of science an Augean stable. At present, however, thanks to the energy and liberality of Mr. T. H. Aldrich, there is sufficient reason to expect, that the paleontolgy of the eastern Old-Tertiary will be soon thoroughly worked up.

Our knowledge of the stratigraphy of the Gulf Tertiary is still worse, inasmuch as the first foundations of it are uncertain. The marine Tertiary occupies a territory extending nearly parallel to the gulf of Mexico through Alabama, Mississippi, Louisiana and Texas. In the last three states and apparently also in western Alabama this Tertiary is separated from the gulf by a formation composed of sandstones, massive clays, etc.,

and designated as the Grand Gulf formation. The relation of this Grand Gulf to the Tertiary affords the following two possibilities. [1.] The Grand Gulf formation is younger than the marine Tertiary north of it and overlaps it. [2.] The Grand Gulf is older than the marine Tertiary and underlies it. In connection herewith stands the stratification of the marine Tertiary itself. In the first case all the strata in general would slope down towards the gulf; in the second case the stratification of the Tertiary would be that of a trough. We may consider a special case. It is generally accepted that Vicksburgian strata occur south of Jackson, Miss. In the first case apparently these strata would be younger; in the second case we may conclude them to be older than the Jackson beds. It must not be overlooked, however, that if the Grand Gulf is older than the Tertiary, we have to expect a trough shape of the Tertiary only there, where the Grand Gulf exists. In eastern Alabama where no Grand Gulf is known to occur, a trough shaped stratification of the Tertiary can hardly be anticipated in any case.

From the foregoing we see that the foundation of the stratigraphy of the Gulf states is the relation of the Grand Gulf to the Tertiary. Until a few years ago, when the writer disputed the validity of the existing theories, geologists did not think of the possibility of the Grand Gulf being older than the Tertiary, as the contrary was considered to be proved beyond a doubt by Hilgard. And only at a recent date Hilgard again repeated the statement, that the Grand Gulf sandstone is found overlying the Vicksburg strata, "as verified innumerable times." [Science, Jan., 1886, p. 11.] But as for this I can only repeat, that I have been unable to find in the whole known literature a single place described, where the Grand Gulf strata can be seen in direct superposition to the Tertiary. I would therefore, urgently request any one who has information of it to give me a single locality where the Grand Gulf can be seen actually overlying the Tertiary.

Although I found a number of interesting objects in Mississippi, I was not successful in finding a contact of the two formations. I described two localities where strata, which look like Grand Gulf strata are overlaid by marine Tertiary, but unfortunately they only have this appearance, and it cannot be

said that they are Grand Gulf. For the question is made more complicated by the difficulty of determining what are Grand Gulf strata. Mr. Aldrich and myself met cross-bedded lignitic strata without fossils, south of Terry, Miss., which we considered as Grand Gulf. In beds near Brandon, Miss., which look very much alike and which are overlaid by orbitoidic limestone, we found impressions of marine shells. In the typical locality, the bluff near the town of Grand Gulf, I found impressions of several species of Unio. Therefore if the Grand Gulf formation is entirely a fresh water formation, the lignitic sands near Brandon do not belong to it, but it seems arbitrary to consider the sands near Terry as Grand Gulf. In the Grand Gulf bluff I did not notice such lignitic sands. If the synclinal form of the Tertiary should be proved, these lignitic strata may be considered identifiable with the more northern lignitic beds in Mississippi.

The only rock that may with some certainty be regarded as Grand Gulf is the characteristic white sandstone, which occurs in Grand Gulf itself and in many other places, and which is not known in the marine Tertiary. In looking out for a contact of marine Tertiary and Grand Gulf therefore we ought to search for a point where the white sandstone is in juxtaposition with the marine Tertiary. Such a contact might be looked for with some expectation of success in Louisiana at the Washita river. Hilgard says, Am. Jour. Sc., Nov. 1869, p. 339: "According to the observations of my companion, Dr. Walker, who determined the line between this [the Vicksburg group] and the Grand Gulf group on the Washita, lumps of Orbitoides limestone at the foot of Grand Gulf sandstone ridges are the first evidence of the change of the formation."

From the foregoing it appears that one of the foundations of southern geology, the relation of Tertiary and Grand Gulf, must be considered as yet undecided and in connection with it the succession of most of the Tertiary strata remains to be cleared up. Some European geologists seem to understand that I consider the former succession of strata as *proved* to be reversed, but I think this point undecided, although indeeed it seems to me more probable that the Grand Gulf will prove to be older than the Tertiary. Against this supposition the following ob-

jection is usually raised. If we look at a geological map of the U. S., we see that we come from older formations to younger ones, when we go from the interior towards the gulf of Mexico; we pass paleozoic, older mesozoic, Cretaceous and Tertiary formations and finally the Grand Gulf; the nearest to the Gulf, must be the youngest one, evidently all formations slope downwards towards the gulf. This observation, however, does not invalidate the assumption, that the Grand Gulf existed as an island or a peninsula at the time when the Old-Tertiary deposits were formed. If we suppose that all the formations in unbroken succession were deposited in the gulf and gradually uplifted in the way the above objection assumes, then we ought to have the following succession: 1, marine mesozoic formations; 2, marine Old-Tertiary; 3, marine Miocene; 4, marine Pliocene or post-Pliocene; a succession which may be found on the Atlantic coast. In place of No. 3, we have now the Grand Gulf formation. This is not marine and is unlike the Tertiary north of it. If there was nothing but a continuous deposition in the gulf, and an uplifting afterwards in concentric formations why was the process of forming sands, clays and limestones teeming with marine shells suddenly interrupted at the end of the Old-Tertiary period? And why were thick strata of sandstones, massive clays etc., deposited, in which not a single marine shell, but as yet only a few fresh water shells have been found? From the former general point of view I cannot find any real explanation, and those explanations which have been ventured [before the presence of fresh-water shells was known] need only be cited[1] to create a suspicion that there must be a mistake somewhere.

We have thus very little knowledge of the stratigraphy of the Tertiary in Texas, Louisiana and Mississippi. In Alabama, however, the Geological Survey under Prof. E. A. Smith, has brought to light many facts, the main substance of which has been published in the Bulletin I of that survey. The possibility of error in this field is so large that one or more mistakes may have been committed in the work of the survey, but in general one cannot fail to see the great care which has been exercised

[1] See Am. Journ. Sc., Dec., 1885, 12th, and 13th, pages of article.

and the earnest endeavor to adhere to facts and avoid speculations. A clearing up of the relation of the Tertiary to the Grand Gulf seems not to have been attempted. The Grand Gulf is supposed to occur in the southwestern part of the state, but it is doubtful whether a contact can be found there. It is to be noticed here that the survey apparently has shown, that the "white limestone" is younger than the Claibornian beds. This "white limestone" is considered usually identical with the limestone at Vicksburg, Miss., and this would tend to show that the Vicksburgian beds are younger than the Claibornian, therefore younger than the intermediate Jacksonian strata; and hence it would be an argument against a synclinal of the Mississippi Tertiary and further conclusive against the greater age of the Grand Gulf. These conclusions, however, contain some weak points, one of them being the identity of the two limestones, separated by so long a distance. It is of little use, however, to discuss this matter more extensively, in consideration of the fact that the direct contact of Grand Gulf and Tertiary has to be looked for and has to be determined beyond a doubt, and that nothing but this will contribute towards a decision of the question.

THE ATLANTIC GROUP.— The division of the Atlantic group from New Jersey to Florida, comprising mostly younger Tertiary strata has been attempted mainly by Prof. A. Heilprin, and a diagram explaining his views may be found in "explorations on the West coast of Florida," p. 127. So far as I have gone in my effort to work out this part of the Tertiary I have been unable to find that his classification and determinations have been proved. The subdivisions of the Miocene seem to me hypothetical and their arrangement in parallelism with European subdivisions like the "First and Second Mediterranean" in Austria which are themselves stongly attacked, seems to be still more hypothetical. The orbitoidic limestone in northern Florida is with positiveness placed on the horizon of the beds of Vicksburg, Miss. Those specimens of rock which I have seen contain Orbitoides in a species which is not shown to be the Vicksburg species, and probably is different from it; and contain besides a Pecten, which is entirely different from the Vicksburg *Pecten poulsoni* Morton, but which apparently agrees with the Jackson Pecten. These rocks therefore have

not been shown to contain one species which occurs in Vicksburg. If a parallelism with a Mississippi bed was a matter of necessity, one might have thought of Jackson, where a species of Orbitoides, and the Pecten occur; but I think that in the present state of our knowledge any parallelism like that does not rest upon sufficient evidence, and cannot claim to be more than a vague hypothesis. Moreover, on account of this parallelism with the beds of Vicksburg, Miss., Prof. Heilprin calls these and other rocks, which contain nummulites etc., Oligocene. I am aware of no fact that proves that the Vicksburg beds are contemporaneous with those of the typical European Oligocene. On the contrary, the position of these beds in their original state appears to be very doubtful.

Now, to take one example, it will be extremely difficult or impossible for any geologist to prove, that the north Floridian limestones or the beds of Vicksburg in Mississippi were *not* deposited at the same time as the German Rupelthon ;but on the other hand it cannot be wondered at that such hypotheses are considered mere guesses.

The palæontology of the Miocene is in nearly the same condition as that of the Eocene. As a subdivision of the Miocene will mainly be based upon the examination of its fossils the first desideratum would be an investigation and good representation of the Miocene fossils. Until this is done a subdivision can hardly be undertaken with any expectation of approaching accuracy.

GEOLOGY OF THE MONTMORENCI.

BY EBENZER EMMONS, M. D.

[*From the American Magazine, November, 1847.*]

The fall of the Montmorenci, in whatever light it is viewed, is an object of great interest.

Hitherto it has been mostly regarded as an interesting spectacle, magnificent phenomenon, and so it truly is; but leave out of view those striking features which impress the beholder with awe and admiration, still it is well worthy the attention of the traveller and tourist.

I propose therefore, to give a brief account of those points and features which I found interesting, on a recent tour of observation to this cele-

brated spot; more particularly, however, of the geological structure of the fall, and of its immediate vicinity.

The river Montmorenci flows from the mountain woodlands, in a southerly direction, and joins the St. Lawrence seven miles below Quebec. The fall is sixty or seventy rods above the junction of the two rivers, and for this distance it is a deep gorge, with perpendicular sides, which has been formed by the river. The amount of the fall is said to be two hundred and forty feet, though to most observers it appears something less, which is doubtless owing to the great width of perpendicular rock over which the river is precipitated. The water in its descent appears like a broad sheet of white foam, which, contrasted with the dark walls through which the river has cut its way, adds greatly to the beauty and magnificence of the scene, and serves to arrest at once the attention of the observer, and fix him in an attitude of profound awe and astonishment. Leaving at this point all details in relation to the geography of the river and its scenery, we pass to the consideration of the geology of its vicinity, and especially of the fall, which, as I have already said, is a spot of great interest, and to the scientific tourist furnishes some facts which will serve to elucidate the structure of the surrounding region, which otherwise would be quite obscure, or at best conjectural.

The tourist will generally take his departure for a visit to the fall from Quebec. His route, after passing the bridge over the St. Charles is on the Beauport road, the direction of which is indicated by a long row of neat white cottages, which form the village of the same name.

Adjacent to the St. Charles, the country is mostly level, and presents fertile and well cultivated meadows and farms, and for two or two and a half miles no rock appears from which the geology of the district can be determined. The formation at Quebec, as is well known, is the graywacke of authors, consisting of schistose strata, argillaceous slates, thin bedded sandstones, fine and coarse breccias, of a green color, and interlaminated with a shaly bituminous limestone, in a highly inclined position. This rock is lost sight of at the lower part of the city, and disappears at once, and we pass from a high, prominent, rocky ridge to a level and smooth country, apparently undisturbed by any uplifts or other derangements.

On reaching the Beauport river at the southern extremity of the village, the rock which underlies this section of country appears for the first time; it is a black limestone, regularly bedded and nearly horizontal, presenting a remarkable contrast with the highly inclined rocks of Quebec. This limestone does not appear entirely alone, for at a few points a black slate projects above the surface, and occupies a position on the same level as the limestone, against which it apparently rests.

This association of rocks, taken in connection with their position, indicates some derangement; and a close examination would undoubtedly result in the discovery of an extensive *fault, or uplift,* along the line which the road passes.

To be more particular as it regards the designation of rocks, I remark, that the first is very clearly the Trenton limestone, so frequently spoken of in the New York Geological Reports, containing abundance of the Strophomena alternata, and Orthis testudinaria, together with many other fossils, which are known to occur in this rock at various places in the state.

It is equally clear, that the slate is the Hudson river slate, and which has been shown in the reports referred to, to be geologically above the Trenton limestone, though here it appears resting against it.

We now proceed to speak of the rocks at the fall, and here it is necessary to remark, that the strata both above and below will require examination. First, then, above the fall, the rock of the bed of the river is gneiss, and reposing upon the edges of the strata composing the bed of the river is, first, a sandstone, in a horizontal position, loose in texture, large portions of which are stained green by carbonate of copper. It is not over ten feet thick, and is of course unconformable with the gneiss on which it rests. This is the Potsdam sandstone, so largely developed in the northern counties of this state.

The next mass, as we ascend in the series, is made up of boulders, some of which are six or eight feet in length; it corresponds to a mass which occurs at Chazy, in Clinton county, and which has been considered as the upper portion of the Potsdam. It is one of the rare instances in which boulders of this size appear as the constituent parts of the regularly stratified rocks.

Upon these boulders is a compact limestone, with its layers conforming to their regular surface on which it rests. It contains obscure organic remains, principally of encrinites. This mass graduates into a gray crystalline limestone, which is composed mostly of broken encrinites; it is about fifteen feet thick. Succeeding to this gray limestone, is the Trenton, a mass very well developed, and abounding in characteristic fossils. It is at least sixty or seventy feet thick, and presents as a whole the characters of this limestone, in as great perfection as at any locality on the Champlain, or in the Mohawk valley. It is worthy of remark here, that this limestone is an excellent guide in determining the relative position of the lower rocks: it forms an excellent starting point from which to trace the ascending or descending series.

It will be seen from the remarks above, particularly by those acquainted with the lower rocks, that two important ones are absent, viz. the Calciferous sandrock and the Birdseye. The first is sometimes two hundred feet thick, the latter thirty.

This omission is not, however, to be considered as a very remarkable case, though it must be confessed that the Calciferous is one of the most constant rocks in the Mohawk, and along the Champlain and St. Lawrence valleys.

The thinning out and final disappearance of a particular rock is, in fact, one of the common changes occurring in the rocky strata.

Having briefly enumerated the rocks above the fall, it is time to ex-

amine those below. The first I shall speak of is the one forming the great fall. This is rather a fine grained gneiss, and furnishes from some portions of it, carbonate of copper, which stains the sandstone alread noticed. It rises in a perpendicular ledge, and stretches in an unbroken uniform mass entirely across the gorge. It is a naked wall, two hundred and forty feet high, and serves by its great mass, as seen below, to add to the magnificence of the scene.

Against this ridge of gneiss, the black slate of the Hudson river series reposes. Viewed from above, it appears at the first sight to rest upon the gneiss conformably; but upon a close inspection it will be seen that it is in a nonconformable position; the strata of slate are less inclined than those of the gneiss, and the whole arrangement finally appears to result from a derangement of the masses. But we have in this place several sedimentary rocks of different ages, nearly if not quite in contact, resting upon the primary mass, and it might be quite puzzling to determine which is the oldest mass, the rocks above the fall or the slate below, as both rest upon the primary unconformably, and only a few years since the slates were placed in the geological systems upon the primary in the precise position which it here occupies.

The annexed diagram will serve to explain more clearly the relations of the rocks at the fall.

From the facts which have been given, and from an inspection of the diagram, it will probably be conceded that there is at the fall of Mont morenci a fault, or uplift on one side, by which the horizontal masses have been elevated, and a down-heave on the other, by which the slate has been thrown into an inclined position; for an uplift simply would have fractured and elevated the strata, but would have left the slates in their original horizontal position, or perhaps, instead of giving the whole mass an inclined position, would have merely bent their edges. Such a result is not uncommon.

An inquiry may be raised at this stage of our examination, if the Black Slate really occupies a position upon and above the Trenton, why is it not to be found still in place? The answer to this question is at hand; the entire mass of slates, shale and sandstone which constitute the graywacke of authors is entirely swept off. The force from beneath which produced this remarkable uplift, shattered and broke the mass of shales, &c, so that they were exposed to the full force and power of floods and currents of water which have swept over the earth at different periods of its history. We are justified also in bringihg to our aid the transporting power of icebergs, agents whose effects and power have been admitted by the most learned and able geologists in Europe and in this country. That this answer or conjecture is more than probable will be shown in the final report of the Second Geological District, the details necessary to establish such a result not being admissible in the present number of this magazine.

But to return to the consideration of the fault or uplift which produced the fall of the river at this particular place; we are not to suppose that

it is a mere local derangement limited to a few rods, but from what is said in the preceding paragraphs it will be seen that there is very little doubt of its extending south along in the direction of the Beauport road and that the places where the Trenton limestone appears or the black slate is found projecting upward in an inclined position, we are on the line of this fault. But this is not all. We are led to believe, from facts which have been accumulating for several years, that it extends much farther south and is to be found pursuing nearly a north and south course into the state of Vermont, and may be particularly traced on a line connecting Johnson's mountain in lower Canada, several points on the Missisque bay adjacent to the provincial line, and also at the remarkable uplift at Snake mountain, in Addison, Vt. A line uniting those points and several others in the same direction, marks the line of a great disturbance which has deranged the lower transition rocks for at least four hundred miles. It may be that this line of derangement is not continuous, and if continuous there are evidently many points where the force producing it was much greater at some than at others, and which has resulted in the projection of several mountain masses continuous only for a few miles, all of which are on this line, and in this geological formation, and along which we find a remarkable uniformity in the accompanying phenomena. Many of these mountain masses are represented on the best maps of Canada, Vermont and New York, and they may be distinguished from the Green mountains, as they appear merely as outliers in that remarkable range.

I do not propose to go into the proof of the whole doctrine which is advanced in this essay, in relation to this extended line of derangement; the space allotted is too limited, and besides the required details are unsuitable to the character of this magazine. There remains one or two important inquires which may with propriety be placed before the reader before I close, as they are connected with and related to the views which have been expressed in this paper. The first is, may not the great fault which I have supposed to extend through Lower Canada, Vermont and New York, have caused the confusion in the writers on Geology in regard to the lower transition rock, particularly the Hudson river slates and shales? May not the same derangement exist in England and Wales, and have been the cause, at least in part, of their separation from the Silurian system, and of their being considered as one distinct therefrom, and which has been called the Cambrian system?

In this state it seems to be established that we have these rocks (the slates, &c., of Hudson river) in two positions, the horizontal and the inclined. They occur in the former position at Pulaski, Lorraine, Rodman, and Pinckney, and they are conformable both in position and fossils to the so-called Silurian sysem. Again they occur in Rensselaer and Washington counties in Vermont, and the entire length of Lower Canada, in an inclined position. Through this great extent of country they are mineralogically the same as the Pulaski and Lorraine shales, and differ from them only in their inclined position. But over this great extent

they agree with what has been published by English geologists of the Cambrian rocks, leaving of course out of view the lower portions of this system, which are either those of shales in an altered state, or else are the true primary. The suggestion contained in these remarks that the Cambrian rocks are really a portion (but not the lowest portion) of the Silurian, has been a conviction of my own mind for a long time, and I find that others entertain the same views.

It is a conviction which has been gaining ground with the progress of discovery, but which has not resulted from any single discovery of itself.

But it is proper to notice here one souree of difficulty in regard to the rocks of Hudson river, especially on their eastern border. It is the fact of their overlapping in this direction, the Trenton limestone and the other transition rocks beneath. The consequence has been that, in traveling from east to west, or from Massachusetts and Vermont to New York, we pass directly from the primary mass to the higher members of the transition system, consequently they have placed them upon the primary, and considered them as the lowest of the transition; whereas, there intervenes between these Hudson river slates and primary, the Trenton limestone Birdseye, Calciferous, and Potsdam sandstone, the aggregate thickness of which exceeds a thousand feet. Not one of the lowest members of the transition system appears in the eastern prolongation between the Highlands of the Hudson and the Highlands north of Quebec, adjacent to the primary, in consequence as has already been said, of the overlapping of those rocks formerly termed graywacke, or now known as the Hudson river series. There are two other difficulties which have served to perplex and confuse geologists, viz.: the striking mineralogical character of some of the masses of the Hudson river series, to the talcose slates of the primary, and also the great correspondence in kind and amount of their dip.

I am not able for want of space to speak of these difficulties. It is evident, however, that the slates and shales do not conform to the primary, they rather rest against the primary, and though in both the dip is to the east, still the constant dip of the slates is less than in the primary. There is a fact which is worth pursuing and which has some bearing upon this question, that is the slates of the Hudson river and lake Champlain are placed between two different mountain systems—the ranges north of the Mohawk valley, all of which clearly compose one system, and the Green mountains which is another. The force which may have served to produce one or the other of these systems may have caused this remarkable derangement in the slate system, producing at the period of their elevation the derangement called a downheave. The known facts, however, are not sufficient to establish the mode and manner in which these border rocks as they may be termed, (meaning the slates and shales), were deranged. They are not of great thickness where they are horizontal, but when inclined, they appear to be immensely thick. In crossing the formation, for example from east to west, it is apparently 20 or 25 miles thick, for as yet it has been impossible to recognize the

recurrence of a single stratum in this distance, yet it may be possible hereafter. In whatever manner the force really operated, it seems to have produced an effect analogous to that of a plough in turning up successive furrows, leaving them parallel and standing upon their edges. There can be no doubt, however, that in the twenty-three or four miles east of the Hudson, the distance which these rocks extended, there are numerous repetitions of the same layers, for it cannot be supposed for one moment that any of the formations above the primary can be of this enormous thickness, which observation seems to indicate.

I must now close my remarks, having extended them farther than was intended when I commenced. I have done this, however, in hopes that some of my observations may induce others to follow out some of the suggestions. Probably there is no field more interesting than the one in which these observations have been made, nor one which is so obscure and which, therefore, will require a multitude of observers before it can possibly receive its full and perfect elucidation.

GEOLOGY AS A MEANS OF CULTURE.

BY ALEXANDER WINCHELL.

II.

3. Diversified aspects of Geological Study.

Unlike mathematics and many other subjects of study, the science of geology consists of various ranges and kinds of knowledge. It is not a mere body of facts of observation, like political or physical geography in the ordinary acceptation; nor of facts of record, like history in the scholastic sense. It is not merely a field stocked with the products of imagination and sentiment, like popular literature. It is not merely a realm of abstract concepts and necessary ideas, like metaphysics. It is not merely a system of deductive processes all firmly bound together and to first principles by necessary laws of thought, like mathematics. It is not merely a department of mental activity where conclusions are balanced on probabilities, and moral certitude is the highest satisfaction afforded the aspiration to know, as in many ecclesiastical, political and educational questions. It is all these, and more than these. Geology as the science of the natural world, embraces all which the natural world contains;

all with which it is historically and genetically connected, and all the accessories and means whose employment contributes to the attainment of a knowledge of the world in its widest relations. It is the organization of all the sciences in a crusade for conquest in the realm of the unknown. To illustrate and justify a claim so large, I shall venture to recite in brief the processes by which geology advances from the most familiar facts of observation, step by step through generalizations higher and higher, to the grandest doctrines ever enunciated by science; and thence by a reverse, or deductive process, to the details of events from which actual observation is separated by intervals of space and time to finite powers impassable.

The beginning of all this fabric of geological science is what we see by the roadside, in the field, on the mountain slope or the ocean's strand. In our daily observations are the facts which point the way to the loftiest generalizations of the science. Let me confine the reader's attention to a group of phenomena leading toward the fundamental *doctrine of a cooling globe.* About our very doors lie the bowlders whose hard and crystalline character proclaims the agency of intense heat. In the structure of the mountains which we climb, and underneath the lands which we inhabit, are square miles of rock similarly crystalline and vitrified. These are data of observation. They are data of easy and familiar and universal observation. They sustain the inductive conclusion that intense heat has been there. Other observations on ancient lavas—on palisades, dikes and extinct volcanoes, indicate that the heat has been sufficient to fuse the rocks. Has been—but is now no longer. *The heat has subsided.*

Thermal springs, geysers, artesian borings, deep mines, volcanic eruptions supply other observational data from which we induce the doctrine of *a heated interior.* The earth has cooled, but is still hot within. *The earth is in the midst of a cooling process.*

This is a most fruitful principle. If the earth is a cooling globe, two inquiries next press upon us. Through what phases of existence has it passed in its remote history; and what vicissitudes is it destined to undergo in the future continuance of the cooling processes? From what initium did the cooling process

set forth, and at what finality will it end? No one can fail to understand that these are lofty inquiries; and that any well grounded responses must lift our thoughts into the realm of sublime truth. But the history of the earth's cooling unrolls a vista through the past eternity. No human intelligence has been witness of the events. The future career of the cooling globe lies in the folded possibilities of events unreal and stretching into the eternity lying in the opposite direction.

But these lofty questions are not unanswerable. The events of terrestrial history succeed according to methods which lie revealed. There is no uncertain caprice in their order and relationships. Physical events run in grooves. What we observe discloses a trend which may be followed in either direction. By observation we have learned the laws of cooling, and the elemental and climatic changes which depend on changes of temperature. If the earth be a cooling globe we may with confidence deduce its conditions and their concomitances in the earlier stages of cooling. Here our reasoning becomes *deductive.* We proceed from the inductive principle of a cooling globe, and from the primary principles of thermodynamics, and retrace the cooling history. We see in imagination as we recede, a warmer terrestrial surface, a more tropical climate, and, in correlation, more tropical plants and animals. We strengthen and verify the deduction by the inductive data afforded by the successively deeper sheets of ocean sediment. Farther on in the retrospect, the sediments are but beginning to accumulate. The mountains are still in embryo; the ocean is universal. As the scroll of terrestrial history continues to unfold, the ocean itself is noticed at its natal epoch; the clouds are discharging the ocean from their bosom. Here the possibilities of inductive confirmation disappear. Earlier than this no enduring rocky forms had existed. The greater heat had reduced all terrestrial matter to a fluid state, which retained no records. This is the starting point of inductive geology.

But this is not the starting point of the process of cooling. With the eye of imagination under the calm guidance of the reasoning powers, we behold in the remoter past, a world of firemist, with the beginning of a central nucleus of molten matter. In the profounder depths of the eternity past, the fire-

mist is conceivably in the condition of a gas. In a history of cooling, we have learned of no condition antecedent to this. The gaseous state of matter accompanies the highest temperature known. Do not understand me as enunciating the doctrine that the cooling process must have begun at a temperature at which all terrestrial matter existed as a gas. I mean only, that the process of cooling leads always away from that state as the remotest possibility. Actually, it may have proceeded from a condition thermally subsequent to this. The subsequent thermal condition may have been attained from some older state in which the constituents of the world were gathering together, and were yet even at a low temperature. I am not seeking to reason out that condition of the world which was absolutely primordial. I seek only to illustrate how by an inverted deduction, we may recede toward a state of the world which antedates all human observation and even all the rocky records of inductive geology.

Now, having found a starting point—having assumed any remote condition as a starting point, we pursue by direct deduction, the course of events which under the laws of matter, must have ensued in the progressive escape of heat from the terrestrial mass. We reason out the attainment, sooner or later, of the firemist condition, the precipitation of a molten rain and the growth of a molten globe, the condensation of aqueous vapor, the enveloping of the earth in a mantle of clouds, the descent of æonic rains, and the gathering of the universal ocean. Many other events collateral with these, we logically reason out. By the aid of imagination, the scenes enacted become vivid and real, and our understanding of them improved. Now we see how and when marine precipitation must have begun, how the submarine floor by thickening, became melted off by encroachment of heat from below, and how as sedimentary deposits continued, the deep-seated residual heat invaded upward the earlier sea-sediments and transformed them. We see how and when the time arrived for the possible introduction of organic forms, and how they succeeded each other as the rolling æons of cooling wrought the terrestrial surface into changed conditions. Of all these post-crustal events, the crust has retained some records, and the inductive evidences from them check and verify our deductive inferences.

Let us for a moment stand on a higher plane of observation, and rise to a higher generalization. There are other planets within the range of our vision which exist under the same forms and motions and accompaniments as this planet. They are regulated by the same system of laws; they consist of the same matter; they undergo the same visible vicissitudes. Here is a body of data of observation—not indeed, with unaided vision, as when we noted the aspects and conditions of the vitrified and crystalline rocks—but with the aid of the telescope, the spectroscope, the polariscope and the crucible. From these data we formulate the inference that all the planets revealed through our instruments are bound together in one system, have had a common history and are moving to a common destination. This larger generalization produces in our minds a conscious expansion—a larger apprehension of the scope and unity of the cosmic plan. This higher attainment of thought is attended by a grateful emotion, a spiritual delight; and if we are philosopher enough to contemplate plan as the correlative and expression of mind, we feel here, in the presence of this grand disclosure, a higher certitude of Supreme Mind, and a deeper seated and more enduring sentiment of devotion.

At the level of this loftier generalization, we conceive the matter and the forms of all the planets merged in one. Perhaps the common mass is in the state of firemist, and luminous. Perhaps it is a heterogeneous assemblage of mineral particles and masses undergoing condensation, and destined in a later æon, to evolve the heat which will develope luminosity and reduce portions to a state of firemist. As before, I care not to define precisely the actual state of the matter of the solar system which was primordial. We seek only a rational commencement—a condition such as involved all later conditions. There must have been a time—so we reason—when the evolution of heat began to be surpassed by loss of heat. From that epoch cooling and contraction began. Rotation is a primordial, necessary condition of all separate masses of cosmic matter. In a rotating, cooling and contracting spheroid, the changes of form and condition resulting are the subjects of calculation. Even if there be alternative lines of vicissitudes, one of these leads on through processes of annulation and spheration—with possible

secondary annulation and spheration—on to such an outcome as we see exemplified in the assemblage of planets and satellites constituting our solar system. And this earth on which we dwell is a particular outcome of such an evolution—so grand, so vast, so ancient. And all that is now of the earth was involved in those æonic vicissitudes. The bone and flesh and nervous matter of our bodies existed in that primordial fire-mist—in those annulating spheres—in that fervid atmosphere—in those glowing rocks—in those ancient sediments—in the shells of primeval molluscs—in the framework of generations of reptiles—enduring as matter; and our plans of organization give expression to thoughts no less enduring. Such is the unity of the organism of the planetary system, and such the unity of man with the organism of the worlds.

In this regressus of thought, we rise to a still higher plane. The sun appears as the residuum of a prolonged process of planetation. By the aid of our instruments we learn that the stars are other suns. Imagination kindles and emotion warms at the suggestions of such a fact. The stars then, are so many centres of planetary systems completed. Yes, to the utmost limit of the visible universe, the same modes of world-life prevail as are exemplified in our own system—the same as are revealed in continental masses and granite cliffs and ocean sediments on this orb to which we have been assigned as its inhabitants. There must be then, other planets. There must be other inhabitants. If other inhabitants, their intelligence is akin to ours; for otherwise, the universe around them, so interpretable to us, would be uninterpretable to them; and the fitness of things which reigns everywhere within our cognizance, would be turned into contradiction of the testimony of the universe. Reason refuses to credit this. Other intelligences there are, to whom the universe has the same meaning as to us; who think as we think; who are already familiar with our ideas, or are ready to receive them and to impart to us their own.

Does not the reader find such ranges of thought expansive, ennobling, spiritualizing? Possibly he is saying this is not geology. No—not in the school-book sense. But geology in the stricter sense leads to the high-swung bridges over which thought passes by an uninterrupted continuity of path into the

realms of philosophy and theology, whose light tinges the clouds which engirt a primeval world. I suffer myself to follow thought into these remoter realms for the purpose of showing the vastness of the range of geological contemplation, though the ordinary geologist may seldom explore it. Geological facts and doctrines, with which we are all chiefly occupied, lie in a single province of the science.

I said that the grooves of passing events run into the distinct future as into the distinct past over which the reader has been transported by a rapid flight. By direct deductive reasoning from the generalized principle of a cooling globe, we are able to depict future vicissitudes with no less certainty than those past. We anticipate a frozen world and a darkened sun. From the generalized doctrine of slow continental degradation we depict beforehand the destructive work of future ages. From the action of the moon on the lagging lunar tide, we are enabled to foresee a lengthened day, and finally synchronistic rotary and orbital movements of the earth, accomplished by a slower action of the sun on the solar tide. Through the operation of a resisting medium—whether ethereal, meteoric or molecular—we look forward to a general gathering of all the dead planets at a common sepulchre. Then by completing the parallelism already delineated in reference to the past, we learn that the unrolled history of this world represents that of all the worlds of our system; and the unrolled history of the system pictures that of the firmament. And now the grand and culminating inference of all science looms before our intelligence in majesty awful and inspiring: The history of matter is one in all the bounds of all space and in all the æons of time past and time to come. The vicissitudes of yesterday are a paragraph in the annals of universal matter. In that totality every human life is a constituent part. Man stands in the midst, and casting his mental glances backward and forward, affirms and feels his unity with all. *Man only as an organism.* Those glances are not the rays of sun or star—they are the thoughts which imperishable and unchanging mind has written on the forms of star and planet and organism. And thus, out from the forms of matter as they perish and disappear, rises an entity which neither changes nor disappears, nor yet endures as mindless matter—

but endures in self-consciousness and self activity, and constituting my essential self, unveils to vision another universe where suns neither wax nor wane, and the limitations and infirmities of changeful matter never interrupt or ruffle the gentle current of eternal being.

4. The Intellectual Powers which Geology calls into exercise.

These thoughts are presented with no intent to expatiate on the themes of science. My purpose is only to indicate the vastness of the range of cognitions and contemplations to which the study of geology invites. It begins with simple facts of easy *observation*. It calls the *percipient powers* into pleasant exercise. In observing separate facts we *compare* them with each other. By processes of *judgment* we pronounce tnem identical or similar or diverse. If similar we *abstract* the particular characters in which the similarity consists, and decide whether they are trivial or fundamental. The wide ranges of facts brought under observation are distributed into groups. *Names* for the facts there must be, and thus arises a technical nomenclature, which gives us additional exercise in *verbal memory*. In extending our knowledge of facts beyond the sphere of personal observation, we resort to the records of the observations of others. We are led to the use of *foreign languages*. We obtain the cultural benefits of *linguistic study*. Our various groups of facts lead to various *generalizations* or interpretations. One group points to a former high temperature on the earth, as we have seen. Another convinces us that the lands have been covered by a universal sea, and that the bedded rocks are but its sediments. Another group indicates the magnitude of land erosions in the past, and the complete obliteration of ancient continents. Another group of facts establishes the doctrine that the earliest animals were invertebrates; and that the oldest vertebrates were marine; and in short, that the order of succession in the advents of animal types was identical with the order of rank—thus contributing one of the principles on which we base that higher generalization which expresses the method of Supreme Mind in all the successions of the natural world. Within each of these broader and more obvious generalizations

are others of more limited scope. If the first vertebrates were marine, so the first marine vertebrates were not fishes of typical structure, but of archaic forms now long extinct. If land vegetation appeared after marine, it was at first only a flowerless jungle. The great body of geological *doctrines* consists of inductions like these, founded upon facts of observation. Many, very many of the facts are near and familiar; many are remote and unfamiliar. A large part of the body of geolgical science consists of a *record of facts*. The generalizations are not, indeed, postponed till all the facts of the science are catalogued. We begin to draw our generalizations while yet we must hold them as merely tentative. Final generalizations may displace them; and even these in some cases, may prove not to be final; or may prove to be wholly erroneous. By a law of our minds we begin to generalize as soon as two or more cognate facts are brought together; and continually test and revise our generalizations, as long as new facts of the same group prove incompatible with earlier generalizations. Then we have reached a principle or doctrine. Thus it is a doctrine today that Dinosaurs did not survive the close of Mesozoic time. But if tomorrow we find the remains of Tertiary Dinosaurs, that generalization must be rectified.

Thus in dealing with the great body of geological science, we keep the observational faculties in training. With this, we exercise the powers of *sense-memory* and of *language*. This training holds a large place in the exactions of geological study. So far as trained quickness and exactness of perception constitute mental culture, the study of geology is eminently cultural. In dealing with the same great body of the science, we keep the *inductive powers* in constant exercise. Their activity, as I have said, is the characteristic activity of modern intelligence, in distinction from mediæval and ancient thought. If the training of the mind in those methods of activity which tend to identify it with modern thought, and make it master of the characteristic results of modern thought is a useful training and a desirable training, then the habits of inductive reasoning fostered by geology constitute an eminently valuable form of mental culture.

But with these studies come various forms of incidental culture. Many of the facts are recorded in works of travel and de-

scription written in style of high literary excellence. Allow me to cite Hugh Miller's "Old Red Sandstone;" Major Powell's "Exploration of the Colorado River of the West;" Captain Dutton's "High Plateaus of Utah," and Miss Bird's "Fire-Fountains;"—or in a different field, the Duke of Argyll's "Unity of Nature." If the student is called upon to record his observations, as well he might be, he may acquire a copiousness of diction and a beauty of style not inferior to that promoted by essays on historical or romantic themes. More indirectly, come the acquisition of languages and the enrichment of the vocabulary.

With these forms of geological study will be noticed an accessory training of the *imagination.* The picturing power is demanded even in bringing into juxtaposition in thought, absent data of observation which have to be compared together. Still more is it demanded in acquiring a vivid comprehension of data presented through descriptions. Especially is this demanded in the study of descriptions of fossil remains unaccompanied by delineations; and not less in the drawing up of such descriptions. I know palæontologists who declare that a mere description of a fossil shell is unintelligible; but, provided the description is good, it would become intelligible with improved picturing power in the imagination. The facts show that in the study of descriptions of fossil remains, and other facts not fully illustrated by drawings, the imagination is kept in constant exercise. The cultural results on this faculty are therefore of great effectiveness and high value.

In an accessory way also, comes discipline in the *art of delineation.* It is impossible for the geological observer to record his observations without the ability to accompany them with drawings. If the student has had no instruction or practice in drawing, he will soon obtain the practice, and then the instruction will be unessential. On almost every excursion, the student or investigator must execute from nature geological sections or geological maps. Not unfrequently, he must delineate some fossil which cannot be removed from the rock, or embody some delineation in a description. I am aware that finished drawings exhaust much time, and are commonly confided to special artists. Still, drawing is one of the demands of geological study and in

vestigation; and this artistic acquirement is one of the forms of culture for which the science of geology provides.

The same demand for pictorial illustration leads the field geologist to subsidize for his ends, the superb picturing power of the photographic camera. Topography, mountain forms, rock-structure, details of stratification, water-falls invite to the application of the camera while in the field; and the exact delineation of fossil forms is greatly promoted by photography in the laboratory. Thus the geologist is led still further to diversify his accomplishments, and add to the sources of his efficiency as a geologist, and of his enjoyments as a lover of nature.

These various forms of mental exercise and discipline are incident to the acquisition of the facts and doctrines of geologic science. I have illustrated a higher range of geological truth, and I wish to impress the fact that its acquisition calls into exercise another range of intellectual powers. The faculties of *deductive* or *a priori* reasoning come into play in the attempt to proceed from an admitted principle to the particulars which it involves or necessitates as consequences. Geological investigation very *freqnently* takes the deductive form. It does not often proceed from *necessary* principles, as in mathematical reasoning; but generally from a principle or truth established by previous inductive research. When a distinguished American geologist described a large number of three-toed tracks found in the brown sandstones of the Connecticut valley, and ascribed them to extinct species of birds, the elder Agassiz reasoned deductively when he declared that they could not be bird-tracks, since birds, according to all inductions, had not begun to exist at so early an age of the world. Similarly, the geologist declares that coal will never be discovered in the valley of the Hudson river, however black and misleading some of the slates may be; since all productive coal measures have been found to hold a higher stratigraphic position. More marked and prolonged employment of deductive inference is observed in the treatment of those geological problems which admit of the application of the methods of mathematical analysis. Some of these problems are as follows: The temperature of the earth's interior; the thickness of the earth's crust; the condition of the central matter of the earth; the existence of tidal effects in the

earth's general mass; the greatest possible altitude of mountains; the sub-meridional direction of mountain chains; the sufficiency of mountain-wrinkles for the total of mountain folds; the existence and position of a zone of no stress in the crust of a cooling planet. Then in that higher range of geological investigation which may be styled comparative geology, or an application of the doctrines of geology to the conditions and histories of other planets, we find many uses for mathematical methods; as in the study of the moon's atmosphere, and her general physical condition; the conditions of Jupiter, and of Saturn and Uranus, and the light they throw on past and future conditions of our own planet.

Without the application of mathematical analysis, the general processes of deductive reasoning from the principle of a cooling world, afford, as I have shown, large and valuable exercise for the higher intelligence. It is a regal power by which we explore in thought the distant ages of terrestrial history which elapsed before even the race of man existed, or the æons of cosmic vicissitudes undergone before even the world had existence. It is a regal power by which we may stand here and glance down through the æons of terrestrial changes yet future. The past has been real, but the future is unenacted. The intellectual eye, through the telescope of geology, pierces through all potentiality. It is prophetic. It enables us to live alike in the æons of the past and the æons of the future. It confers on us a limited omnipresence and omnipotence. No enlightened man can possibly deny that such exercises of mind are lofty, noble, cultural—cultural and improving to an extent scarcely paralleled in the circle of human thought.

There are those—among them a few geologists—who affirm that these lofty deductive reasonings are little more than flights of the imagination, and that the results do not belong to the body of recognized science. These men conceive geology as properly restricted to its body of facts and generalizations. It is easy to show that such a dogma is impossible of observance, and is violated daily even by those who acknowledge only positive geology. But a thoughtful consideration of the mode of evolution of our grand deductive conclusions will show that they are *reasoned out*, not imagined. The difference between a

pure romance and a romantic inference is as wide as the beginning and conclusion of terrestrial history. It cannot be claimed that the particular denouements which we picture have been or are to be actual events. The pathway of reasoning often bifurcates, and we may pursue either road to conclusions. There are always concomitances lying alongside, which are the outcomes of causes acting outside of our trains of reasoning. These may determine whether the actual course of events will pursue the right or the left. We know however, that it will pursue one or the other; or at least some course within the scope of rational anticipation. With all these qualifications and uncertainties of actual detail, the sublime fact remains, that our science enables us to mount into the æons past, and plunge into the depths of the æons to come, and get visions, even if dim, of the stupendous events flowing out of the exercise of infinite power and infinite intelligence in the realms of infinite space and infinite time.

Let me add that if these visions are absolutely unreal, the exercise of the intelligence is still the same. It is an exercise of the loftiest powers of the mind, and if it leaves in our possession no real knowledge, but only culture, it stands on a footing equal with some other studies deliberately pursued simply for their cultural influence—and that, even on a lower range of faculties than those employed in the higher inductions and deductions of geological science.

It must have occurred to the reader that much yet remains to be said of the cultural influence of the higher reasonings of geology. I allow myself a few words further. Imagination, I said, is not the creator of the histories, past and future, which I have depicted in the vicissitudes of the world; but it is the indispensable instrument for securing to the understanding a vivid apprehension of the reality, the nature and meaning of those vicissitudes. These exercises of the higher reason keep imagination in constant and pleasing activity, and thus train a power which sheds over the logical products of the mind a vivid radiance, and often lights the way for the understanding into the dark regions of the unknown.

The loftiness of these themes demands a lofty style. To portray them to the common intelligence—always eager to learn

of them—demands such imagery and metaphor and lucidity and earnestness as belong to the higher ranges of polite literature. If a good *use of language* be one of the results of culture, here are examples for imitation, and here are opportunities for scholastic exercise.

In commencing this discussion, I proposeed to confine my treatment to intellectual culture, but the friends of geology might well charge me with remissness, if I should fail to remind the reader again, of the *moral* and *spiritual improvement* which comes from such contemplations as I have pointed out respecting the unity of the realm of nature, and the revelation of Supreme Intelligence which we read everywhere in the plans and methods of nature.

I could not say more within reasonable limits of space. Enough I hope, has been said to establish the proposition that the study of geology is *suited for universal culture.* In its various grades and departments it calls into exercise *every power of intelligence*, and even comes into moving relations with the *ethical susceptibilities.* What more is universal culture? What more is symmetrical culture? Who can claim any discipline of intelligence as not reached by the influence of geological learning? I shall not institute comparisons in detail. I leave it to my readers to seek out other lines of study capable of a wider or more profitable culture. Their efforts will but enforce the truth of my conclusion.

I am not so unreasonable as to maintain that geology is the only science to be studied; or that other sciences or literatures do not afford particular kinds of culture to a greater extent than geology. I only desire the truth to be discerned and acknowledged, and acted upon, that geology is a study capable of culture more diversified than is found in the pursuit of those studies often prescribed exclusively for their cultural value.

I have presented geology simply as a means of culture. I have not considered it as a *means of useful knowledge.* An elucidation of the utilitarian side of geologic study would show that in geology we possess the means of uniting general culture with the attainment of useful knowledge. Thus is doubled the claim of geological study upon our regards as educators and promoters of the best civilization.

These positions being established, it might still remain to examine the relations of geological science to the developing intelligence of the young. Though this also is a field which cannot now be entered, it would be easy to show that many of the observational data of the science are precisely suited to the stage of intellectual development of young pupils; other data, and the inferential principles of the science, to pupils of progressively maturer years. And finally, it would be easy to illustrate practically the observational method of introducing the familiar elements of geology to pupils of tender years, and proceeding by gradual expansion and elevation of the method, to ranges of geological thought suited to pupils of full maturity.

I leave the subject to the reader's reflections. What I have said is true or untrue, or partly true and partly untrue. If true, educators cannot, as reasonable persons, permit the science of geology to remain under their reproach and neglect as a materialistic science—a "bread and butter science." They must act; they must acknowledge the truth, and allow geology to come into the enjoyment of its rights in the field of education. If what I have said is untrue, my positions demand an impartial refutation; for a wide and powerful public sentiment is gathering at my side. If they are partly true, I shall continue to maintain that the true is the larger part, until my numerous and powerful literary friends honor my views with the electric light and heat of their destructive criticism.

PROF. AMOS H. WORTHEN.

BY E. O. ULRICH.

Prof. Amos H. Worthen, so long state geologist of Illinois, and curator of the State Museum of Natural History, died of pneumonia on Sunday, May 6th, 1888, at his home in Warsaw, Illinois.

Prof. Worthen was born at Bradford, Vermont, October 31st, 1813, and hence had nearly reached the ripe age of seventy-five years when death overtook him. He was the son of Thomas

Worthen, and on his mother's side, a descendant of the highly esteemed and distinguished Adams family. He was the youngest, save one, of thirteen children, and received his education in the common schools of his native town and at Bradford's then famous academy. On January 14th, 1834, nearly a year before attaining his majority, he married Miss Sarah Kimball, of Warren, N. H., who proved his faithful and life-long companion, her death having preceded his only a little more than a twelvemonth. In August, 1834, he emigrated to Kentucky, but before the close of the year he began teaching school at Cumminsville, now a suburb of Cincinnati, Ohio.[1] Here he remained for two winters when, in June, 1836, he removed to Warsaw, Ill., which became his permanent home. With his brothers-in-law, the Kimball boys, he became first a forwarding and commission merchant and later dealt in dry goods at Warsaw. In 1842, influenced by the depression in business, caused by the Mormon difficulties in Hancock county, he removed with his family to Boston, Mass., returning, however, in July, 1844, to Warsaw. Before going to Boston his attention had been strongly attracted to the geological features of his new home and the fossils preserved in the sedimentary rocks of that region. The geode beds in particular had commanded his admiration and close investigation. Even at that early period he felt within him the stirring of that spirit of investigation and love for natural science that later caused him, first to neglect, then to abandon entirely all business less suited to his tastes, and to devote himself to science with a singleness of purpose and a devotion as rare as it is honorable and profitable to the individual and to mankind. Armed with basket and hammer, all his spare moments at that time were spent in rambling over the bluffs and among the ravines, so that soon his collection contained many beautiful and interesting geological specimens. When he went to Boston he took with him several barrels of fine geodes then so abundant at Warsaw. These with a naturalist's true love for his (to be) calling, he exchanged, instead of selling them, for a cabinet of sea-shells. Similar forms to

[1] In 1886 the writer had the pleasure of escorting the old gentleman about Cumminsville, which he had not seen for fifty years, and he (Prof. W.) was more than gratified to find his old landlord still alive and hearty.

these shells were preserved in the limestones and shales of his locality, and he worked diligently to learn something of their history and of the specific characters of the animals to which they once belonged.

This task was one of great difficulty since the only works he had been able to obtain that contained any account of fossils were Dr. Mantell's "Medals of Creation" and "Wonders of Geology," both published in England. These threw but little light upon the specimens he had gathered, but they gave him an insight into the manner in which the rocks had been formed and how the remains of living forms came to be preserved in them.

His collection grew apace and soon began that extensive system of exchanges with other scientists that gradually not only furnished him with the information so much desired, but also made both his cabinet and knowledge valuable enough to command the attention of leading eastern geologists. Many of his fossils were loaned by Prof. James Hall and illustrated in the report on the palæontology of Iowa. Prior to this time (it was in February, 1851) a law had been passed authorizing a geological survey of Illinois, and two years later an appropriation was made to carry it out, and Prof. Norwood appointed state geologist. Prof. Worthen did some work under him but soon (in 1855) engaged in more active work in Iowa under Prof. Hall. In the meantime the work in Illinois languished; although five years passed, no report was made and when on March 22nd, 1858, Gov. Wm. H. Bissell placed in the hands of Prof. Worthen his commission as state geologist, nothing of prior work came to his hands save a report by Prof. Norwood on the lead mines of Harden county and the field notes of his assistants.

On taking charge of the survey Prof. Worthen at once began earnest and active field work, in prosecuting which he has probably carried a greater bulk and weight of geological specimens than any other geologist of his day. He also secured for the work the assistance of some of the ablest specialists—notably Prof. Leo. Lesquereux in palæobotany and Carboniferous stratigraphy, Dr. J. S. Newberry and Prof. Orestes St. John in vertebrate palæontology, Prof. F. B. Meek and Mr. E. O. Ulrich in invertebrate palæontology, Prof. J. D. Whitney in mineral-

ogy, Dr. J. V. Z. Blaney in analysis, and Mr. Henry Engleman in chemistry. He also had the countenance, support and friendly aid of numerous lovers of science in all parts of the state, and though hindered and harassed by unscrupulous and ignorant opposition to the survey, as so plainly stated in the preface of the first volume of his reports (published in 1866) was enabled to issue a series of seven volumes which are of great scientific value and a credit and honor to the state, while they are to him a monument of industry and ability. He had also the plates and manuscript of an eighth volume complete, but its publication was delayed by the trouble about the state printing during the last session of the General Assembly. This volume was considered by him as the final one of the series, and, believing his mission to be accomplished, he intended to resign his position at Springfield as soon as it had passed through the printer's hands.

Prof. Worthen's labors related principally to the Carboniferous series. To him belongs the credit of being the first to work out the true relations of the principal divisions of the Lower Carboniferous system, though the inflexible rules of priority may demand that the names proposed by other laborers in this field should stand for them. The value of his work was recognized by his election as honorary member of several European scientific societies. He was also a member of the National Academy of Sciences of this country.

Regarding his character the more salient features were: great love for scientific truth and justice, simplicity, unbounded affability and unswerving integrity, coupled with an unpretentious yet strong desire to accomplish a useful career. His generosity and charity scarce knew bounds, while, in his public and private life, his frank and sympathetic nature and unassuming, yet dignified demeanor won the esteem of all with whom he came in contact.

EDITORIAL COMMENT.

THE PARLIAMENT OF SCIENCE IN THE UNITED STATES.

It is the task of the historian and sociologist to determine how far the example set by the fathers of our republic in reverting to the old and eminently just idea of representative and popular government, influenced the action of all guilds, professions and classes of society in making concert of action in order to secure greater power, broader views, and more systematic progress; but it is certain that the idea of combination has been growing steadily during the past century until scarcely a case where it will apply is untried.

Corporation, corner, and trust on the side of capital are met by organization, boycott, and strike on the part of labor; and from the editorial staff composed of the ambitious pupils of the boy's schools to the eastern alliance of undertakers, every temporary association of human beings either through personal propinquity or a community of business interest is made to produce that strange thing, abstract in reality, yet so much wiser, stronger and more formidable than any one or two of the component parts of which it is formed, called a society.

Of course this tendency has extended itself to science which is of the classes which can derive the greatest benefit from such community of work and unity of purpose, because creative science or original research, in penetrating beyond the domains of the known, needs every help which the most varied experience and the soundest induction can give it, and these are derived not from a few but from many minds. It is true that here is a class of soi-disant geniuses which keeps itself from being entirely forgotten by denying the utility of all those postulates which centuries of experience have produced, who succeed in imitating real genius only in the degree and not in the kind of its eccentricities, and in nothing else. This class is delighted in making the plodders stare at its sweeping denials of all the fundamental principles to which the investigation of truth for its own sake has led, and substitutes for them a smart

sounding paradox which too often is to sciolists what the sepia is to the cuttle-fish; but the large majority of those who do the scientific work of the world are neither deceived nor diverted by this charlatanism, and prefer to seek strength in numbers and a near approach to accuracy in averages.

Gradually the idea grew, probably insensibly to its promoters, until from a mere chance gathering of a few scientific men interested in geology, a confederation of scientific workers arose which includes within itself every domain of human thought applied to the discovery or evolution of new truths. This confederation is called the *American Association for the Advancement of Science*, and it is the Home of Representatives of American science.[1]

Of course the Senate of science in the United States must be

[1] Note. The first session of the society which organized as the "Association of American Geologists" was held in the rooms of the Franklin Institute of Philadelphia on April 2. 1840 or a little more than 48 years ago. There were present Edward Hitchcock, Amherst, Mass., Lewis C. Beck, New Brunswick, N. J., Henry D. Rogers, Phila., Lardner Vanuxem, Bristol, Pa., Wm. W. Mather, Brooklyn Ct., Walter R. Johnson and Timothy Conrad, Philadelphia; Ebenezer Emmons and James Hall, Albany, N. Y., Chas. B. Trego, James C. Booth, M. H. Boyé, R. E. Rogers, and Alexander McKinley, Philadelphia; C. B. Hayden, Smithfield Va., Richard C. Taylor, Philadelphia, Douglass Houghton and Bela Hubbard, Detroit Mich. Prof. Hitchcock was appointed chairman and Prof. Beck secretary.

The second annual meeting was held in the Academy of Natural Sciences of Philadelphia. Prof. Silliman took the chair.

The third session was held in Boston. Dr. Morton the chairman being absent Prof. Locke was called to the chair.

Lyell was present at this meeting and "offered some observations on the distribution of boulders aud furrows in the rocks, citing the results of many observations in Europe.

A constitution and by-laws were adopted and a list of 77 gentlemen "who had been present at the meeting or had presented communications to the Association" was added to the printed proceedings of the three meetings. The Association adjourned to meet in Albany on the fourth Wednesday in April, 1843. These notes are followed by 462 pages of transactions and 22 well executed plates. [See *Reports 1st, 2nd, and 3rd., meetings, Am. Ass. Geol., and Nat., Boston; Gould, Kendall, and Lincoln, 1843.*]

At the Boston meeting of this body (which had become the Association of American Geologists and Naturalists") held in 1847, it was agreed to resolve itself into the *American Association for the Advancement of Science*. It met for the first time in its new form in the Academy of Nat. Science in Phila., on the third Wednesday (20th, day) of September 1848. Prof. Wm. B. Rogers, the last president of the former organization introduced Wm. C. Redfield Esq. the first president of the new one. (See vol. 1, of the *Proceedings A. A. A. S.* Phila.; Jno. C. Clark, 60 Dock St.)

assumed to be the National Academy of Science, both on account of its limited membership and the exclusive manner in which additions to its members are made. A few words will be devoted presently to a consideration of how well these two bodies carry out their mission.

The objects of the popular body of American scientists are said to be[1] "by periodical and migratory meetings to promote intercourse between those who are cultivating science in different parts of the United States; to give a thorough and more general impulse, and a more systematic direction to scientific research in our country; and to procure for the labors of scientific men increased facilities and a wider usefulness."

The first part of these objects sufficiently explains why the meetings of the Association are not *exclusively* given up to scientific discussion.

One important function of these meetings is to enable men of the same or cognate branches of science to meet, compare notes, make each other's acquaintance and secure those numberless and nameless advantages which only personal intercourse can secure. For this reason as much time as can be spared from the sessions of the *Sections* is well employed in social reunions which are not of a character to interfere with the talking either of "shop" or of commonplace between contemporary workers in science.

These recesses are well employed in doing this, and probably bear as much fruit in the end as the more technical discussions of papers, which latter are necessarily much restricted owing to their large number and the short time which is available to hear them.

But too much time ought not to be devoted to these recesses under the guise of receptions, garden parties, excursions, &c., &c., because every meeting of a large number of persons from widely separated districts offers an opportunity for the systematized exchange of ideas (as in the discussion of papers in Sections and the like) which it costs a great deal of money and exceptionally favorable circumstances to bring about. There is one respect in which the leaders of our scientific Congress are derelict, *viz.:* in allowing the desire to excel previous feasts to

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[1] See first paragraph of "Objects and rules of the Association," vol. I. *Proc. A. A. A. S.*, p. 8.

inspire the ambition of the citizens of the place where the Association meets to outdo all records of hospitality, and by this to encroach upon the precious time which might be devoted to mutual efforts to get nearer to our goal. Another fault is in filling the five days of the meeting too full.

It is marvelous that the local committees will never grasp the fact that the visiting members of the Association ever want to be let alone—to be free to do whatever they please, or to rest from the whirl of kaleidoscopic changes and deeds with which it is a local committee's pleasure to surround its helpless victims.

Take an instance haphazard from the little document called the "Programme A. A. A. S.," omitting names of persons and places.

First day.—Morning. Meeting of Standing Committee at 9 A. M. Organization of Association meeting in general session at 10 A. M. Meeting called to order. Invocation by ———. Resignation of chair to the president elect. Welcome on behalf of local Committee by ———. Reply by the president elect. Announcements by general secretary. Announcements by permanent secretary. Announcements by local secretary. Morning sessions to begin at 10 and close at 12:30. Afternoon session to begin at 2 and close at (?). * * * Adjournment of general session and organization of the *Sections* in their respective halls. Each section is to elect one fellow to the standing committee; three fellows who with the vice-president and secretary shall form the sectional committee; one member or fellow to the nominating committee; three members or fellows to act with the vice president and secretary of the Section to recommend to the nominating committee a vice-president and secretary for the next meeting. Secretaries of Sections report the organization to the general secretary. Secretaries of Sections report program of their respective section for the next day.— Afternoon addresses of the vice-presidents in their respective halls.—*Evening*: Address of retiring president in general session. (First day pretty well filled.)

Second day.— Morning: Meeting of Sections in their halls, 10 to 12:30 and 2 to 6.—*Evening:* General reception to members and their families.

Third day.— Morning: Meeting of Sections at 10 to 12:30, and afternoon 2 to 4. *Evening:* Reception.

Fourth day: Excursions all day.

Fifth day: Meetings of Sections, 10 to 12:30. *Afternoon.*— Meetings of Sections, 2 to 6. Excursions during the same afternoon. *Evening.*— Two receptions. Same evening lecture and collation.

Sixth day.— Mornikg: General session. Election of officers for next meeting and decision of place of meeting. Meeting of Sections till 12:30. *Afternoon.*— 2 o'clock meeting and final adjournment of Sections. *Evening.*— General session. Concluding exercises and adjournment.

Summing all this six days work up it amounts to this: The first day is consumed in organizing and listening to addresses; the sixth day is consumed in electing officers and winding up the affairs of the meeting. Of the remaining four days one is entirely given up to excursions; another is half given up to the same purpose. Or in other words thirteen hours are given to organizing and disorganizing; sixteen hours to excursions during the day, and (at a most liberal estimate) fifteen hours and a half are devoted to the business which has ostensibly called this crowd of people together from distant parts of this and sometimes of other continents. That is to say, counting as the average one day and a half, which it has taken them to reach the place of meeting, and the same time to get home, there have been spent out of 216 hours in all 15½ hours in the discussion of subjects of science.

Taking the Buffalo meeting of 1886 as a sample of the number of papers which are disposed of at an ordinary meeting at the present time, it will be found that excluding the addresses of the vice-presidents, there were papers read as follows:

		Read.	Read by title.
Section A.	(Mathematics and Astronomy)	11	13
" B.	(Physics)	19	8
" C.	(Chemistry)	—	30
" D.	(Mechanical Science)	13	6
" E.	(Geology and Geography)	36	8
" F.	(Biology)	19	17
" H.	(Anthropology)	15	13
" I.	(Economic Science and Statistics)	5	5

There were thus 119 papers considered in eight Sections, or about an average of 15 to a Section, under better auspices than could have been attained by printing them in a scientific journal. The reading and discussion of each of the papers could have occupied one hour had they all been of equal length and interest. But they were not. Some of the papers took an hour each in the reading, and in some of the Sections (notable that of Geology and Geography) an average of less than half an hour apiece was awarded to the reading and discussion of each paper. When one looks at the titles and names of authors this time will be sure to be absurdly inadequate to the purpose. Again 100 papers were never read at all, and only secured the empty honor of being read and printed by title, though it would be hard to imagine what purpose is served by such a disposition.

Two hundred and sixteen hours at an expense of say fifty

dollars on the average are expended by every one who attends one of these meetings for fifteen hours and a half of reading and discussion of papers. So much for the actual individual participation in the meeting.

But it may be said that the seeming discrepancy between the expenditure of time and the compensation for it is corrected by the publication of the volume of *Proceedings* wherein the gist of all the best of what has been written (though without the discussions which are often more important than the papers) is permanently preserved as a record.

Let us see how far this is realized in actual fact, and for this purpose let us take the last volume of the *Proceedings* issued by the A. A. A. S., that is, the volume of the thirty-sixth meeting held in New York, August 10, 1887.

This volume contains 368 pages counting everything numbered with Arabic numerals, besides 98 pages of preliminary matter numbered with lower case Roman numerals. This latter comprises ten pages of title and contents; one page of officers of the meeting; one page, officers of the council; pages xiii to xvii inclusive (five pages) of local committees of the meeting; two pages of special committees of the Association; four pages of past meetings and officers of the Association (to page xxiv); one page of the act of incorporation; eight pages of constitution of the Association; pp. xxv. to xcviii inclusive (seventy-four pages) of patrons, (two-thirds of whom are patronesses), members, fellows, and deceased members. Then begins the record of science proper. Of this, forty-four pages are devoted to the admirable address of Prof. E. S. Morse. Following this are eleven pages of the report of the committee on indexing chemical literature, and one page of the report of the committee "on anatomical nomenclature, with special reference to the brain."

Officers of Section A take a page. Eighteen papers take eight pages, making less than an average of half a page to a paper. Ten of them are printed by title, that most useful form for persons who wish to learn something of the subject.

This brings us to page sixty-seven. The officers of Section B. [Physics] occupy a page; the address of the vice-president, Prof. Anthony, takes ten. Twenty-two pages following the address hold thirty-eight papers, of which all but fourteen consist of nothing but a title.

The usual page being allowed for the officers of Section C. [the chemical Section,] the vice-presidential address of Prof. Prescott occupies eighteen pages while forty-three papers (six only by title) are crowded into twenty-two pages. It is worthy of remark that eleven of these papers are by the same person, Prof. T. H. Norton, three by another, Prof. C. F. Mabery, both of Cincinnati; and two by Mr. F. G. Novy. None of them were however, read by title. The papers in Section D. (Mechanical Engineering) take up twenty-five pages (with five pages more of the joint session of D and I) of which twelve pages are occupied with the address of vice-president E. B. Coxe. Twenty-three papers (including the joint session referred to) are condensed into twenty-one pages.

Section E. [Geology and Geography which may be considered the nucleus of the whole Association, since the latter was evolved out of the Geological Society] occupies forty-seven pages, of which twenty-four pages fall to the share of vice-president Gilbert in his attack on the International Geological Congress; forty-six papers [of which twenty-six are printed by title only] are laid upon twenty-two pages, leaving a little more than a page on the average to each of the twenty papers actually printed in abstract.

Section F. [Biology] claims forty-six pages, nineteen to the list of officers and address of the vice-president, and forty papers [of which eight appear only by title] are condensed into the twenty-seven pages of text which remain.

Section H. [Anthropology] is furnished thirty-seven pages; twenty-one of list of officers and address, and thirty-one papers (nineteen by title) are squeezed into sixteen pages.

Section I. [Economics] has thirteen pages to the end of the vice presidential address; and twelve papers (seven by title) are printed on *three* pages of text.

To sum up—there are nine pages of lists of officers; 114 pages of vice-presidential addresses; 151 abstracts of papers read, occupying 141 pages; and 100 papers read by title.

At page 339 commence the executive proceedings with four pages of speeches, and five pages of routine business. Two pages contain all of the proceedings of the executive committee relating to subjects of science, and two pages are devoted to that

kind of complimentary resolution which has been euphoniously called in the British Association, "butter."

An appendix to the report of the general secretary, giving the excursions and entertainments, fills one page, and the financial statement of the permanent secretary five pages. Ten pages are devoted to the index.

To recapitulate.

159 pages of presidential and vice-presidential addresses.
141 pages of abstracts of papers printed, 100 not printed.
Six pages of speeches and "butter."
Six pages of financial statement and excursions.
Two pages of action on scientific matters.
This is all that is published in the annual volume.

Each Section has its secretary who is presumed to make minutes of all matters acted upon by the Section, and to forward these notes to the permanent secretary, but they nowhere appear in print, and the writer is officially informed that if any member of the Association wishes to know what action has been taken by the Section he addresses the permanent secretary who then looks over the minutes of that Section handed in and, if the inquirer be a member of the Section about the action of which he seeks information, the permanent secretary writes to him giving it.

No opportunity is given to correct erroneous minutes before the Section adjourns, and these minutes, never having been read to and approved by the Section, are unreliable. By the next meeting there is a complete change of officers and no one has at his finger's ends the business of the last session.

The evil effects of this want of system are most marked, and extend to complete confusion as to the state of important matters. Having occasion some time ago to look up the history of a certain special committee it was found that, owing to the complete ignorance of what had been done at previous meetings, first, two different committees had been confounded and merged into one; second, a committee having been finally discharged was re-endowed with life on the statement of one of its original members that he had a report to present from a committee entirely outside of the American Association and which could not by any possibility report to the Association. Yet this self-

contradictory statement was gravely received, and unanimously passed, and, lo! a new committee deprived of some of the names on the old one, and containing several more upon it (though a totally different committee) was declared to be in existence and ordered to act.

Would it not be better to substitute a magazine weekly or monthly as the official organ of the American Association and print in it *in extenso* all the important papers which have been favorably passed upon by a competent and impartial committee? The editing of this magazine would require the attention of a number of the best equipped members of the Association and the selection and replacement of these would furnish additional material for Association politics. In this manner all that was worthy in the contributions would be set forth in full. Two columns of one number might be devoted to the "welcomes," the "officers," the "excursions," and the "butter."

Would it not be well to let important meetings of Sections go on irrespectively of whether a hospitable individual had invited the entire Association to an excursion or not. Recently on the occasion of a most important Section meeting which had been formally devoted to the consideration of a subject, the presiding officer not only refused to allow any vote to be taken to express the sense of the Section, but actually was so moved by the exigency of the moment which although not even a full minute he declared to be that at which those who were to participate in a 'water party' should leave the meeting, that he put a vote to adjourn, with rare courtesy on his part and that of the mover, in the middle of a sentence of a speaker and refused to allow the speaker even that thirty seconds which must elapse to a full minute, to complete it. This should be made impossible, for it is easy to see how under possible circumstances a biased presiding officer might deprive members of the Association of their rights in order to aid some private intrigue of his own.

Let the business of the Sections go right on, excursions or no excursions, only leaving time enough unfilled to allow all who wish to take a reasonable amount of scientific excursion. The Association will always furnish enough people who take

no interest in the papers read to make any excursion, in numbers at least, a great success. Steady work, less ceremony and more pages of science would help science greatly at the hands of the Lower House.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On the history and character of the genus SEPTASTREA, *D'Orbigny (1849,) and the Identity of its type species with that of* GLYPHASTREA, *Duncan (1887.)* By GEORGE JENNINGS HINDE Ph. D., F. G. S. (Quarterly Journal of the Geological Society, May 1888.)—In this paper which like all the published work of the author, presents in brief space, with lucid and concise statement, the result of laborious investigation that is satisfied with nothing short of exhausting the subject in hand, Dr. Hinde shows the identity of the genus *Glyphastrea* of Duncan with the older genus, *Septastrea* of D'Orbigny.

The genus *Septastrea* was founded on a species of massive or sub-dendroid corals found in the Tertiary deposits of Virginia; and from the paper under review we learn that it was originally described in 1849, in a small pamphlet that seems to have had but a limited distribution, since no copies of it are to be found in the scientific libraries of London.

The genus was recognized and described by Messrs, Edward and Haime in 1849, and since then, as Dr. Hinde very clearly shows, it has had a recognized place in paleontological literature.

When M. M. Edwards and Haime re-defined the genus *Septastrea*, they referred to it with appropriate description a supposed new species from the Tertiary of Maryland under the name of *S. forbesi.* D'Orbigny subsequently claimed *S. forbesi* E. and H. to be a synonyn of *S. subramosa* D'Orbigny, a statement at least confirming the generic identity of the individual specimens to which the names *S. subramosa* and *S. forbesi* had been applied. The fact that *S. forbesi* was the first species of the genus properly described would in accordance with the rigid rules of nomenclature insisted npon by such writers as Hinde in England and Ulrich in America, make *S. forbesi* E. and H. the type of the genus, *S. forbesi* E. and H. would be all the more firmly established as the tpye if, as claimed by D'Orbigny, it was identical with the nominal species *S. subramosa* D'Orbigny.

More recently professors Duncan and Fromentel referred certain Mesozoic corals of the Jurassic period to the genus Septastrea; these Jurassic corals however, were not congeneric with the forms used by D'Orbigny and M. M. Edwards and Haime in establishing the genus.

In December, 1886, Prof. Duncan read a paper on a new genus of corals, the publication, however, being made in February, 1887. In this paper the absence of generic identity between the Mesozoic and Tertiary corals that had been referred to *Septastrea* is recognized, but curiously enough the author proceeds to separate from *Septastrea* the Tertiary species, including *S. forbesi* E. and H., on which the genus had been founded, leaving the Mesozoic species that had been erroneously referred to it to stand as types of *Septastrea*, and making *S. forbesi* E. and H. the type of a new genus, *Glyphastrea.*

Dr. Hinde claims, and apparently with much propriety, that *Septastrea* must stand as originally defined; and must embrace at least its type species *S. forbesi* E. and H., and all forms congeneric with this species. *Glyphastrea* of Duncan, which is founded upon *S. forbesi* E. and H. as its typical species, must therefore be regarded as simply a synonym of *Septastrea* d'Orbigny.

The last part of Dr. Hinde's paper is devoted to an exhaustive discussion of the structure and characters of the species properly belonging to the genus *Septastrea.* The structure is studied in its minutest detail, and much light is thrown on the mode of growth, not only of the species in hand, but of corals in general.

The paper is illustrated by a plate embracing seventeen figures.

Note on the spicules described by Billings in connection with the structure of Archæocyathus minganensis. By George J. Hinde, Ph. D., F. G. S. (Geol. Mag., Dec. III, vol. V.) The genus *Archæocyathus* has been something of a puzzle to palæontologists ever since its characteristics were made known by the researches of Billings in 1861. In the "Palæozoic Fossils of Canada," first on page 3, and afterwards on pages 354-357, Billings discusses more or less fully the relationships of this peculiar genus, and is disposed to regard it as a sponge with certain characteristics allying it to the corals. The view that it is a sponge is strengthened by the fact that spicules of peculiar character have been found either in the walls of the fossil or in the rock adjacent to it. Two kinds of spicules were found, one elongate, fusiform, the other branching.

The researches of Hinde show that the elongate spicules are only accidentally associated with *Archæocyathus* and consequently have no significance in determining the relationships of the genus.

On the other hand its branching "spicules" described by Billings are not regarded by Hinde as exhibiting the characters of sponge spicules at all, but would rather seem to be irregularly broken fragments of the outer wall or *theca* of the fossil. The spongide affinities of Archæocyathus, if it has any, must rest upon some other basis than the presence of spongelike spicules in its walls.

On the chert and siliceous schists of the Permo-Carboniferous strata of Spitzbergen, and on the characters of the sponges therefrom, which have been described by Dr. E. von Dunikowski. By George J. Hinde, Ph. D., F. G. S. (Geological magazine, Decade III, vol. v.) This paper is of especial interest in connection with the paper of the same

author on *The Organic Origin of the Chert*, noticed in the February *Geologist*, page 121. A specimen of chert, forwarded to Dr. Hinde by Prof. G. Lindström of Stockholm and collected from Permo-Carboniferous strata of Spitzbergen, was found on examination with a hand-lens to be almost entirely composed of spicules of sponges irregularly intermingled. The geological horizon of the beds furnishing the chert in Spitzbergen is nearly the same as that at which the spicule-bearing chert of Ireland and Yorkshire was obtained. Indeed, according to Hinde, the Spitzbergen beds "form the upper portion of a series of rocks regarded stratigraphically as the equivalents of the Carboniferous Limestone, even though they contain a certain admixture of Permian fossils."

American Geological Classification and Nomenclature. By JULES MARCOU. Cambridge, Printed for the author, May, 1888. In this pamphlet of 75 pages the author gives us a general discussion from his point of view of the classification and nomenclature of the geological systems, divisions, etc, of North America. Strong arguments are presented in favor of the claims of the *Taconic System* as a term to denote the rocks containing the first fauna. The pamphlet, however, is throughout so largely controversial, and discusses so many points of interest to geologists in general, that instead of giving what would necessarily be an unsatisfactory outline of the points treated, we refer readers of the "Geologist" to the pamphlet itself.

Three formations of the middle Atlantic slope. By W. J. MCGEE— (American Journal of Science Feb., April, May and June, 1888.) In these four papers which are now bound together and distributed by the author in pamphlet form we have the results of considerable work on some hitherto obscure formations developed in the middle portion of the Atlantic slope.

The first to be described in the paper, and the first in geological sequence, is the *Potomac formation*. Reference is made to this formation and to the Dinosaurian remains that have been obtained from it, in the GEOLOGIST for February, 1888, page 136. According to McGee the Potomac formation extends from Weldon, N. C., through the intervening region, into New Jersey. South of the Rappahannock it is exposed chiefly along the waterways, while to the north of the river mentioned the formation is exposed at the surface over considerable areas, appearing extensively in railway cuttings or capping eminences of circumdenudation.

One of the chief points of interest in connection with the Potomac formation is the fact that it helps to supply some of the hitherto missing portions of the geological record. One instance must serve as an example. The great break that has heretofore existed in the history of the development of our forest flora is now partially filled up. Cycads and conifers were the predominant types in the early Mesozoic forests. But cycads and conifers are pre-eminently archaic types, connected by means of a more or less perfect series of gradational forms with the earliest terrestrial flora. In the Cretaceous forests we have poplar, sassafras,

willow, oak and trees of modern type as the predominant forms. Angiosperms have supplanted gynmosperms, and the transition has had all the appearance of having been suddenly accomplished. The Potomac formation furnishes in part a history of the transition. Here we find a curious commingling of archaic and modern forms; and not only that but here are also species in which the ancient and modern types are mingled in the same individual. A modern external form may be combined with an old-fashioned internal structure.

The modern student of geology has never doubted that the oaks, willows, maples, poplars, etc., described by Lesquereux from the Dakota group, were not the earliest Angiosperms. They must have had their predecessors; and those predecessors, all would have agreed, must have been comprehensive types combining characters belonging to the older and the newer floras. The Potomac formation furnishes us a glimpse of some of these predecessors, with ancient and modern characteristics mingled and blended in precisely the manner we should have anticipated.

The second formation which has been added by the investigations here recorded to the geological series is called the Appomattox formation. The beds of this formation are found at a number of localities, but their principal exposures are on and near the Appomattox river from its mouth to some miles west of Petersburg. It consists, in part at least, of orange colored sands and clays. In places it overlies directly the Potomac formation, but in some places it is seen above fossiliferous Eocene beds and in others it even overlies the Miocene. It is newer therefore than the Miocene, but its age has not been definitely settled. It has furnished no fossils.

The third of the formations here described is called the Columbia formation from the district in which it has been most carefully studied. This formation attains its greatest thickness along the river and thins out in the places between. The materials of the Columbia formation vary greatly, grading from fine silt to coarse sand, gravel, pebbles or bowlders up to a foot in diameter. In places the material is more or less perfectly stratified. The formation is newer than the Appomattox. Its fossils, consisting of the remains of the reindeer, elephant, mastodon, elk, etc., would indicate that the formation belongs to the Quaternary. It belongs to the earlier rather than the later Quaternary, however, for it is found passing under glacial drift, and by the amount of erosion and degree of alteration in it, it is proved to be "much older than the terminal moraine or the drift sheet whose margin it marks."

The deposits of the Columbia formation are all sub-estuarine and bear testimony to a submergence of the region in which they occur of at least 150 feet. Coincident with the submergence was a long-continued depression of temperature. Indeed the deposits bear evidence of two epochs of cold that were separated from each other "by an interval three, five, or ten times as long as the post-glacial interval; that the earlier cold endured much the longer; that the earlier cold was the less intense and the resulting ice sheet stopped short (in the Atlantic slope) of the limit

reached by the later; that the earlier glaciation was accompanied by much the greater submergence, exceeding 400 feet at the mouth of the Hudson and extending 500 miles southward, while that of the later reached but a tithe of that depth or southing; and that during the long interglacial interval the condition of land and sea was much as at present."

On the Syncarida, a hitherto undescribed synthetic group of Malacostracous Crustacea. By A. S. PACKARD. (Fifteenth memoir, vol. iii. Proceedings National Academy of Sciences.) Dr. Packard in this paper discusses the taxonomic relations of some interesting fossil Crustacea from the Coal-Measure shells of Mazon creek, near Morris, Illinois. The forms were first described by Meek and Worthen in the proceedings of the Academy of Natural Science, Philadelphia, and were afterwards figured and described by the same authors in the geological reports of Illinois, vol. iii. The group of Crustacea in question is represented by the genus *Acanthotelson.* Dr. Packard had placed at his disposal for study a large suite of individuals and the results of his investigations lead him to conclude that "the characters of this crustacean are such as to forbid our referring it to any known group; we therefore suggest that it forms the type of a sub-order of thoracostracous Crustacea, which we would designate as the *Syncarida.*"

The presence of a telson and the structure of the last pair of abdominal appendages in Acanthotelson indicate relationships with macrouran decapods; but the absence of a carapace, and the division of the thorax into distinct, equal segments causes it to resemble the Edriopthalmia. The statement of Packard is that these Crustacea "form a connecting link between the Amphipoda and Thoracostraca, but at the same time in their most essential characters stand much nearer to the Schizopoda than to the Amphipoda."

It is the same old story. The ancestral forms of our modern fauna and flora were *synthetic types.*

In the same Memoir as part II, Dr. Packard treats of The Gampsonychidæ an undescribed family of fossil Schizopod Crustacea. The types of this family are also from the Coal Measure shells of Mazon Creek, Illinois.

As part III of the same memoir we have a paper by the same author on the Anthracaridæ, a family of Carboniferous macrourous decapod Crustacea. The type of this family is the *Anthrapalæmon gracilis* of Meek and Worthen. Mazon creek is also the locality from which the material was obtained.

The sixteenth memoir, vol. III, proceedings National Academy of Sciences is devoted to a paper by Dr. Packard, on the Carboniferous Xiphosurous Fauna of North America. We have here practically a monograph of this remarkable group that shows such interesting relationships with our modern king-crabs on the one hand and with trilobites on the other.

The Carboniferous Xiphosura are divided by the author into three families, 1, Cychlidæ, represented by *Cyclus americanus* Packard, 2, Dipel-

tidæ, containing *Dipeltis diplodiscus* Packard, 3, Bellinuridæ which contains three species distributed in two genera: namely, *Prestwichia danæ* Meek and Worthen, *P. longispina* Packard, and *Bellinurus lacoei* Packard.

It will be observed that the author does not retain the genus Euproöps of Meek and Worthern, but places the species referred to that genus under Prestwichia.

Patæontology is indebted to Dr. Packard for his pains-taking work in determining the relationships of these peculiarly interesting Carboniferous Crustacea.

An article in Pall Mall Gazette written by Mr. J. A. Symonds describes the dangerous wind-blast that accompanies avalanches. Though of meteorological rather than geological interest it brings into prominence an agent that may produce effects of importance in geology and we are therefore tempted to quote it.

"The Fluela pass which connects us with the Lower Engadine is closed to traffic. Just before noon a man named Anton Broker, known among his comrades as 'the Knave of spades' because he had a bushy black beard, was swept away by an avalanche. Eyewitnesses saw him carried by the blast together with his horse and sledge 300 yards through the air across the mountain stream. The snow which followed buried him. He was subsequently dug out dead, with his horse dead and the sledge beside him. The harness had been blown to ribbons in the air, for nothing could be found of it except the head-piece on the horse's neck."

"The violence of the wind that precedes an avalanche is well authenticated. A carter whom I know once told me that he was driving his sledge with two horses when an avalanche fell on the opposite side of the gorge. It did not catch him but the blast carried him and his horses and the sledge at one swoop over into deep snow whence they emerged with difficulty." "A road-maker was blown this winter in like manner into the air and saved himself by grappling a fir tree."

"In order to understand the force of the Lawinen-Dunst as this blast is called here we must remember that hundreds of thousands of tons of snow are suddenly set in motion in narrow chasms. The air displaced before them acts upon objects in its way as breath blown into a peashooter."

In the Quart. Journ. Geol. Soc., London, Feb., 1888, Dr. Henry Woodward describes a trilobite recently discovered in the great slate quarries of Col. Peurhyn, near Bangor, North Wales. He refers it to the genus Conocoryphe (C. viola).

This discovery is of great interest because no fossils have previously been found in these quarries though millions of tons of slate have been taken out during the past half century; another illustration of the small value of negative evidence. It is also important because it adds another to the scanty fauna of the Lower Cambrian.

The Lower Cambrian consists of the

Harlech grits	6000 feet
Llanberis slates	3000 feet

and the fossils in question were found near the top of the lower portion. Generally speaking these beds may be paralleled in America by the Paradoxides-bearing strata found in different places, as at Braintree, Mass., St. Johns, New Brunswick, and eastern Newfoundland, &c. But it is doubtful if any beds as old as the Lower Cambrian or Llanberis slate are yet known in the United States or in Canada.

C. viola is about three inches long by one inch and three quarters wide, showing that the trilobites of that early day were not the smallest of their kind.

The fauna of the Longmynd or Lower Cambrian group of Britain is thus summed up by the author.

Sponges	1	Brachiopods	2
Ostracods	2	Pteropods	2
Trilobites	7	Annelids	3

Making a total of only seventeen or with the new trilobite eighteen species.

There is some discord between the various statements in this paper. In the table the number of trilobites is said to be seven, whereas eight are enumerated above by name. Again in a footnote the whole number of trilobites known from the Cambrian rocks is given as eighty-five whereas in the table the total is 101. There is nothing to show that different localities are intended so that the inference is natural that the results relate to all.

Dr. Traquair of Edinburgh discusses in the Geological Magazine for May, several points in the relations of the relics of fossil fish to one another.

He is inclined to think that the evidence does not bear out the opinion he formerly advanced that *Ctenacanthus* and *Cladodus* were the spine and tooth of the same fish, and that *Hybodus* was to be placed with them. He now believes that *Hybodus* is distinct from both and that further knowledge will distinguish *Cladodus* from *Ctenacanthus*. He dissents from Mr. Garman's opinion that in the recent and recently discovered Japanese shark *Chlamydoselachus anguineus* — which is spineless —we have a modern Cladodont.

He then shows that one species at least of "*Helodus* and of *Lophodus* belong to the mouth of the same fish, which is a *Psephodus*," and that the anterior teeth of *Psephodus* and of *Cochliodus* are indistinguishable generically from *Helodus*.

After describing a new spine, *Oracanthus armigerus*, relying on the asymmetry of this genus, he maintains that *Oracanthus* is not a fin or tail-spine but the postero-lateral termination of the headshield of some fish covered with a Cephalaspidian buckler. "I think," he adds," "there can be no further doubt that the portion of *Oracanthus* spines is on the head of a selachian and not on the tail of a placodermic ganoid."

Geological and Natural History Survey of Canada; Annual report, (vol. ii,) 1886, Montreal, $2.00. ALFRED R. C. SELWYN, *Director*. This valuable document embraces thirteen parts, devoted to as many portions of

the Dominion, from Nova Scotia to British Columbia, and northward to the Arctic ocean. A unique and important portion of this report is that of Dr. G. M. Dawson embracing a compend of all geological information relating to the northern portion of the Dominion east of the Rocky mountains, reaching to the Arctic shores and including Greenland, accompanied by a colored geological map. This is, so far as we are aware, the first attempt to make a general geological map of these regions.

CORRESPONDENCE.

In vol. iv, March 1888, of the Memoirs of the Boston Natural History Society is a paper by Mons. Jules Marcou entitled "The Taconic of Georgia and the Report on the Geology of Vermont."

In chapter IV, Mr. Marcou describes "The Section at Charlesbourg near Quebec," and what he calls the "Landslides at Montmorency, and in the plate which accompanies the memoir he gives a section (Fig. 8) of the structure from Quebec to Charlesbourg, in which he shows the Trenton limestone resting in horizontal attitude on what he calls the "Swanton and Quebec City slates." These, as I understand, he considers to be a part of the Taconic of Emmons.

On page 130 Mr. Marcou writes "Professor Lapworth says: 'The so-called Quebec rocks of the town of Quebec are not of Quebec age at all.'" This fact was first intimated by me on purely stratigraphical considerations in 1879,[1] and when in 1885 I sent a series of fossils that had then been found in the Citadel Hill rocks to professor Lapworth, he, on purely palæontological considerations, fully confirmed my views, the only difference between us being that while I held the true position of all these shales to be above the Trenton, he is inclined to place them below it. This conclusion, however, rests entirely on the supposition that certain forms of graptolites must occupy the same horizon on both sides of the Atlantic,—an instance of what I have elsewhere deprecated as palæontological stratigraphy.

In the present instance the stratigraphy, which Prof. Lapworth has no knowledge of, has been carefully worked out by Logan and myself, and by other members of the Canadian survey, and I cannot learn that any one ever saw the shales beneath the Trenton limestone, as shown in Mr. Marcou's section, fig. 8.

As regards Mr. Marcou's not very complimentary remarks, page 118, in reference to Logan and myself, I would like to refer him to an article

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[1] Montreal Nat. Hist. Society, 24, Feb., 1879.

entitled, "Geology of Montmorency," copy enclosed, in the American Magazine for November, 1847, by professor Emmons, and he will see that neither Logan nor I, but the author of the Taconic system was the originator of the faults which Mr. Marcou calls "landslides."[1]

Emmons, however, does not appear to have included in his Taconic the Montmorency and Charlesbourg shales, but to have regarded them as Logan did and as I do, (notwithstanding their great apparent thickness and high angle of dip to which he refers,) as holding the position of the Utica Lorraine, but as being against, not on and much less under the limestone as they are represented to be by Mr. Marcou, in his section.

The article referred to is, it seems to me, of considerable interest and importance in view of recent discussions, and I hope the perusal of it will induce Mr. Marcou to reconsider the matter and to modify his views on the subject of the landslides at Montmorency.

As regards the Taconic it appears to me to be very much on a par with the "Quebec group," and like it, will have to be resolved into its elements, which seem to consist of parts of all the recognized formations. from Pre-Cambrian or Huronian and Laurentian to Lorraine shale.

ALFRED R. C. SELWYN,
Director Geol. and Nat. History Survey of Canada.

Charleston and its vicinity continue to be disturbed by earthquake-tremors. A friend who has spent the winter at Summerville—which town it will be remembered is situated nearly over the focus—has shown me a record of all noteworthy shocks observed during her stay, from which I extract the following.

1888, Jan, 12. Very severe shock at 10 a. m. The noise was beyond description awful, and the house rocked to and fro until I thought it must be thrown from its foundations. The furniture in the room continued to shake for some minutes after the shock was over. Some of the ladies were nauseated by the shock.

Jan. 16. A sharp blow under the house at 12.50 and a short shake which made the furniture rattle.

Feb. 1. A severe bump under the house with explosion like a gun going off, at 10 p. m. this evening.

Feb. 12. At least a dozen shocks during the past week but all slight, though enough to wake one when sleeping. Thunder-storm yesterday and three shocks during its continuance.

Feb. 29. Awakened at 6 a. m. by a severe shock which jarred every thing in the room and shook me well up in bed.

Mar. 2. A severe shock at 11 p. m. The house swayed much and the jarring sensation was very disagreeable.

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[1] This important paper of Dr. Emmons is printed in full from the copy sent by Dr. Selwyn. See p. 94.—ED.

Mar. 3. A shock during the night swayed the house.

Mar. 4. Shock last night which waked me.

Mar. 13. Several detonations during the last few days. Severe shock waked me at midnight.

Mar. 13 to 25. Scarcely a day or night has passed without severe detonations and shakes. I felt three during one hour of the 19th, about midnight, as did several other persons in the village. The effect on the house is shown in the blinds, window-catches and door-locks which get out of gear.

Mar. 25 to Apr. 8. Detonations more or less violent almost every day. One on the 4th was the severest of the winter. Property holders much discouraged.

Apr. 16. Very violent shock last night. Was awake when it happened, and for some time before. Heard the advancing roar as it seemed to approach the house. When it arrived the house shook violently and swayed to and fro for some time before it settled again. An hour later the house rocked back and forth without any shaking or noise. Shock at 11 A. M. this morning less severe. Weather for the last few days intensely hot. Heavy thunder and lightning and change to cold weather by the morning of the 17th.

Apr. 19. Detonation and slight shock at 10 P. M., which set all the dogs barking with fright.

May 2. Many detonations during yesterday evening and a very long shake in the night.

The sounds are described by the friend from whose record the above extracts are made as resembling those which would be produced by firing cannon in the cellar and the jars indicate that the waves emerge in a nearly vertical direction at Summerville. The swaying of the houses without accompanying noise or jar may be caused by the propagation of another wave from a center at a greater distance or by the reflection of a wave from below emerging elsewhere.

E. W. CLAYPOLE.

Akron, Ohio, June 10, 1888.

Since my last note to you on the formation of the southside of Long Island, there have come into my hands specimens of sand and clay from a well boring at Woodhaven, about one mile from Jamaica bay and about the same distance from the front of the terminal moraine. The tube-well has been sunk to the depth of 500 feet without finding shells or any other marine matter, going to prove, we think, that the southside of the island is entirely of glacial origin, including the so-called sea-beaches.

The result of the boring so far is as follows:

1 to 113 feet—Fine sand and gravel.
113 " 144 " —Sand and coarse gravel.
144 " 315 " —Reddish sand to 218; from 230 to 275 a tough, whitish clay; from 246 to 315 the clay is mixed with pebbles of considerable size.
315 " 385 " —The clay is mixed with vegetable matter to 358; then beach sand containing pieces of wood or lignite.

448 to 460 feet—Beautiful clear, white sand.
460 " 470 " —Dark peat-like muck, intercalated with clear, white, beach sand.
475 " —Beach sand with no sign of marine matter.

The boring is still going on. I will let you know the final result.

JOHN BRYSON.

1309 Baxter Ave., Louisville, Ky.

The Taconic at Boston. Prof. Hyatt writes to one of the editors of the GEOLOGIST as follows: I have just received your interesting pamphlet (*The Taconic Question*) and read it. Although I withdrew from the committee because I was unable to pay proper attention to this very interesting question, I had made up my mind with regard to the matter, and had adopted in the arrangement of the collections at this society and at Cambridge by permission of Mr. Agassiz the nomenclature which you proposed. Whether this nomenclature is absolutely true or not has been a secondary question in my mind.

It seems to me very evident that the terms, as employed by you, will do justice to all three of the original discoverers of the oldest systems of fossiliferous rocks. They afford a basis of compromise which ought to satisfy all parties interested in doing justice to these three original investigators, and they possess also a certain simplicity and appropriateness which does not appear in the use of other terms.

Very truly yours, ALPHEUS HYATT.

PERSONAL AND SCIENTIFIC NEWS.

THE DEGREE OF DOCTOR OF SCIENCE was conferred recently on Prof. E. W. Claypole, one of the editors of the GEOLOGIST, by the University of London, his *alma mater*.

MR. C. C. NUTTING, ASSISTANT PROFESSOR OF ZOOLOGY and curator of the museum in the State University of Iowa, is spending his vacation in the British West Indies. He is fairly luxuriating in the wealth of tropical life—marine and terrestrial—in that land of sunshine.

Mr. Nutting has been experimenting with success in killing branches of corals, both Madreporaria and Alcyonaria, with the polyps fully expanded. He has also succeeded in transferring them from one strength of alcohol to another without undue shrinkage. The museum and the zoölogical laboratories of the university will be gainers by his season's work.

IN THE COURSE OF AN INVESTIGATION of the superficial deposits of northeastern Iowa undertaken some years ago, Mr. W. J. McGee brought to light several curious relations among the phenomena, including the bipartition of the drift and the intercalation of a forest bed between its members, the existence

of large numbers of rounded hills and elongated ridges apparently corresponding to the kames and asar of Ireland and Scandinavia respectively, a unique distribution of the loess which is here generally confined to the summits of eminences including kames and asar, an anomalous deportment on the part of the rivers of the area, whose general courses are at right angles to the general slope of the surface, and which have frequently avoided driftless valleys and lowlands and have cut considerable canons in the axes of ridges and other elevated tracts. A few preliminary notices of these phenomena have been published, but no systematic report upon the investigations has thus far been issued. It now appears that the delay in publication was due to the necessity for topographic maps exhibiting the unique distribution of the loess and the drainage lines. This requirement was met last summer by a topographic survey of an area of one hundred square miles centering about Iowa City, upon a scale of a mile to an inch with twenty foot contours, and Mr. McGee is now reviewing this area with a view to the preparation of a memoir embodying the results of his various investigations in Iowa.

THE ANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will be held during the week beginning August 15, at Cleveland, Ohio. There is every prospect of a large and successful meeting. The retiring president is Prof. S. P. Langley, Washington, and the president elect is Maj. J. W. Powell, director of the U. S. geological survey. Section E. will be presided over by Prof. George H. Cook the veteran state geologist of New Jersey. Prof. George H. Williams, who was elected secretary of Section E., has resigned. The members of Section E will hold an informal meeting at the Central High School building on Tuesday, August 14, at three o'clock to consider plans for holding sessions between the annual meetings of the Association.

DR. PERSIFOR FRAZER, SECRETARY OF THE AMERICAN COMMITTEE of the International Congress of Geologists, one of the editors of this journal, leaves early in August for Europe. Dr. T. Sterry Hunt, another member of the American Committee, sailed from Quebec for Liverpool on July 12, on the SS. POLYNESIAN, and intends to be absent till October.

THE REGENTS OF THE UNIVERSITY OF TEXAS recently elected Mr. Robert T. Hill, of Commanche, professor of geology in the university. Mr. Hill has so thoroughly studied and described the Cretaceous of Texas that it may be said to be established on a new foundation.

ACCORDING TO W. T. CUMMINS the western area of the Carboniferous in Texas is entirely barren of coal, and in the foot-hills the ovelying Cretaceous is found to dip conformably with the Carboniferous.

THE

AMERICAN GEOLOGIST

VOL. II. SEPTEMBER, 1888. No. 3.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS. REPORTS OF THE AMERICAN COMMITTEE TO THE LONDON SESSION.

The origin and history of this Congress have been given by Dr. Frazer in volume i of the GEOLOGIST. He has also sketched the work of the American Committee to and including its sixth meeting.

The seventh meeting took place at New Haven on December 29, 1887. There were present Cook, Newberry, Powell, Stevenson, N. H. Winchell, Hunt, Williams, Cope, Hitchcock, and Frazer. In the absence of Dr. Hall, Dr. Hunt was elected chairman; and on the ruling of Dr. Hunt, Dr. J. D. Dana was declared an active member of the committee. The main object of the meeting was to receive, discuss and act on some reports that had been received since the Spring Lake meeting. These were presented, and the reports on the *Archean*, by Dr. Frazer, on the *Devonic*, by Prof. H. S. Williams, on the *Carbonic*, by Prof. J. J. Stevenson, on the *Mesozoic*. by Prof. Geo. H. Cook, on the *marine Cenozoic*, by Prof. E. A. Smith, and on *Quaternary, Recent and Archeology*, by major J. W. Powell, were approved and ordered printed. That on the *Lower Paleozoic*, by Prof. N. H. Winchell, and on the *Interior Cenozoic*, by Prof. E. D. Cope, were presented in incomplete form, and final action on them was deferred till the next meeting, which was ordered to be not later than April 1, 1888. The official edition of the report of the American Committee was fixed at 500 copies, of which 300 were ordered to be distributed to the members of the Congress.

The eighth meeting of the committee was held in the Murray Hill hotel, New York, April 2, 1888, at which there were present: Cook, Cope, Frazer, Hall, Hitchcock, Newberry, Stevenson, and N. H. Winchell. The reports on the *Lower Paleozoic* and on the *Interior Cenozoic* were read and accepted, and owing to the withdrawal by major Powell of his report on *Quaternary, Recent and Archeology*, Prof. C. H. Hitchcock was appointed to prepare a digest of American opinion.

The committee by unanimous vote requested Mr. C. D. Walcott to present to it, for publication with its reports, a memoir on the Taconic,

in place of that withdrawn by him, and previously forming a part of Prof. Winchell's report on the Lower Paleozoic. The form, title-page and make-up of the volume containing all the reports in print (of which the editor, Dr. Frazer, presented a sample for inspection) were approved.

A letter was read from major Powell resigning his membership on the committee, but action thereon was deferred till further correspondence be had by the chairman with major Powell.

The committee, in directing the publication of these reports, did not intend to assume, collectively, responsibility for opinions or conclusions expressed by the writers. The reports were accepted and published as the best available expression of American opinion at the time of publication.

Mr. Walcott declined to furnish the memoir requested, but a summary of his latest views, prepared by himself, has been embodied in the report on the Lower Paleozoic.

Résumés of the several reports, each prepared by the author of the report, have been forwarded to professor Dewalque, secretary of the International Committee on the unification of nomenclature, and have been by him translated into French and forwarded to Mr. William Topley, general secretary of the committee on organization of the congress. Mr. Topley has also received the consent of the American committe to have an edition of 750 copies of the American reports printed from the forms at Philadelphia, for publication as "Appendix A" of the volume of the proceedings of the Congress. It was also ordered by the American committee that any of its members should have permission to order any number of extra copies of any part or the whole of the report of the American committee, at his own expense, provided they be left in the custody of the secretary till the meeting of the Congress.

At the late meeting of the American Association for the Advancement of Science, at Cleveland, a report of the labors of the committee preparatory to the London Congress was presented. The report also stated that the next Congress had been invited by the committee and by numerous educational and scientific institutions to meet in America at its next session. This report was accepted and the committee was continued.

All of the expenses of the committee, including the publishing of its report, have been paid by voluntary subscriptions of its own members and some liberal citizens of the country.

INTERNATIONAL CONGRESS OF GEOLOGISTS.

AMERICAN COMMITTEE.

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PROF. N. H. WINCHELL, State Geologist of Minnesota,
University of Minnesota, Minneapolis, Minnesota.

PROF. JAMES D. DANA, LL.D., etc., New Haven, Conn.

SUB-COMMITTEES.

Archean.

J. D. Dana, T. Sterry Hunt, R. Pumpelly,
C. H. Hitchcock, N. H. Winchell.

Persifor Frazer, Reporter.

Lower Paleozoic.

Jas. D. Dana, James Hall, J. P. Lesley.

N. H. Winchell, Reporter.

Associates—C. D. Walcott, A. Hyatt.

Upper Paleozoic.

James Hall, J. P. Lesley, J. S. Newberry.

H. S. Williams, Reporter on the Devonic.

J. J. Stevenson, Reporter on the Carbonic.

Associate—Sir J. W. Dawson.

Mesozoic.

E. D. Cope, J. S. Newberry, J. W. Powell.

G. H. Cook, Reporter.

Associates—W. W. Davis, W. N. Fontaine, R. P. Whitfield.

Cenozoic.

E. D. Cope, J. S. Newberry, E. A. Smith.

E. A. Smith, Reporter on the Marine Cenozoic.

E. D. Cope, Reporter on the Interior Cenozoic.

Quaternary and Recent.

G. H. Cook, J. W. Powell, N. H. Winchell.

C. H. Hitchcock, Reporter.

Report of the Sub-Committee on the Archean.*

PERSIFOR FRAZER,

REPORTER.

PRELIMINARY REMARKS.

THE Congress at Berlin, September 28 to October 3, 1885, took under its consideration the work which had been accomplished by the two previous Congresses (Paris, 1878, and Bologna, 1881), and also the propositions of two International Committees appointed in Bologna to prepare plans respectively for the unification of geological nomenclature, and for the coloration of geological maps. These Committees met at Foix and Zurich, in Switzerland, during the four years which intervened between the Congresses of Bologna and of Berlin, and the discussion, clause by clause, of their reports formed the only important business of the Berlin session. It is proper to begin, therefore, with the propositions either specially pertaining to, or so general as to include the Archean.

For the purpose of making a practical test of the color scheme which had been, in general, outlined at Bologna, but in the perfection of which much discretion was allowed the Committee, it had been decided to produce a geological map of Europe: it being thought that whatever defects existed could be best observed in that portion of the world's crust which was best known to the largest number of geologists; and as to which, owing to

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* According to the rule recommended by the Congress this word should be Archeic, and is so used by the Portuguese and Roumanian Committees (see p. 156), but the form more generally employed is that above, or the same termination with the objectionable middle diphthong.—P. F.

the fact of its being split up into a large number of countries, if uniformity could be attained by mutual agreement, there was a strong probability that the system which succeeded here would be accepted by the rest of the world.* The report of the Committee was published in English in the Report of the American Committee,† as was the action of the Congress upon its various recommendations (pp. 18–21).

Those which passed without question related to (1) the publication of the map, and business connected therewith; (2) its distribution when completed; (3) the scale of the map, *i.e.*, 1 : 1,500,000; (4) the Committee which was charged with editing it; (5) the relation of colors for the Carbonic, Devonic, and Siluric systems, with all of which this report is not concerned; (6) the selection of seven tints of red to represent the eruptive rocks. This latter is contained in Prof. Lossen's scheme for the classification of the eruptive rocks, and will be more particularly considered in another place. It is only of importance to record here that the Congress took no vote on the desirability of this scheme, but left its adoption for a specific object to the discretion of the committee on the geological map. So far, then, as the Congress is concerned, there was no adoption of this or any other scheme of classification or coloration of eruptive rocks except ‡ for the purpose of enabling the map-committee to represent the eruptives according to some scheme, which will be better criticized, when it is seen how it lends itself to representing the facts in the geology of Europe.§

* It is a mistake constantly being made by American geologists, to suppose that the making of a geological map of Europe was one of the fundamental objects of the Congress. It was merely an incident to its purpose of unification; and Asia, America, or any other part of the world might equally well have been chosen as a test-area if the conditions governing the choice of such an area had been as favorable as they were in Europe, which, however, was not the case.

† "The work of the International Congress of Geologists and of its Committees; Philadelphia, 1886."

‡ Ibid., p. 32.

§ The time of the appearance of this map will be the most appropriate for all kinds of criticism of the methods of delineation proposed by the Committee. If, as is hoped, it shall be printed in time for presentation to the Congress in London, that body will doubtless lead the way in a searching criticism which will probably last till its next triennial session, and will result in many changes and much good.

The first question proposed to the Congress seems to be an unusual one, but in the light of investigations made in our own country, recently, and the number of eminent geologists who have adopted the conclusion to which these researches seem to have led, it is perhaps the most important of all. It is, "Shall the Pre-Cambrian be included with the Paleozoic?" Prof. Dewalque in making the proposition adds, "The negative does not seem doubtful," but when Dr. Blanford desired to postpone the question of forming a group of Pre-Cambrian, the former replied that if the group be not accepted, then the Pre-Cambrian strata must belong to the Paleozoic, and Prof. de Lapparent added, if the Pre-Cambrian contain fossils it must be joined to the Paleozoic. This fragment of a discussion states the question as plainly as an elaborate treatise could do it. As Prof. de Lapparent's objection is the most radical, let it be considered in the first instance.

One of the great dangers in classification is the establishment of artificial lines, which become in time real barriers to that free ebb and flow of conception which has always preceded the establishment of a permanent theory.

It would seem in this case as if the necessity of joining the fossiliferous portion of the Pre-Cambrian to the system above it was created by the use of the word "Paleozoic," and by our insensible effort to attain symmetry. "Old life," "Middle life," and "New life" make plausible divisions by organic forms of the rocks containing fossils; and the earliest rocks known to us, if crystalline and apparently lacking in fossils, appeal to the imagination to be accepted as the remains of a first crystallized crust; but with our present knowledge it is generally agreed that we are not justified in considering them so. The subject is of more apparent than real utility in research, and mainly concerns the question whether we have anywhere represented the primitive crust of the earth; for even if it be conceded that the oldest known rocks contained the remains of life at the time they were produced, it will not be denied that a separate division of the same value as "Paleozoic" and "Mesozoic" must be employed for them now. It would seem, therefore, to be an artificial necessity founded upon the tyranny of an etymology, to class the Pre-Cambrian with what we call the Paleozoic whether the former contain fossils or not, provided they differ from Paleozoic rocks in other important particulars.

It is from a consideration of the same kind, viz.: a lack of proper terms which can express the idea at present, that Prof. Dewalque was led to conclude that if the group which he proposed to call Primitive be not accepted, the beds which compose it must be referred to the Paleozoic.

It is of much more importance to decide what limitations "Primitive" or "Archean" should have, if employed separately, or together, or one to the exclusion of the other.

Views of some American Geologists on certain Questions concerning the Archean.

The vote in favor of giving the name Archean to the oldest known crystalline rocks was very large in the Congress of Berlin; even the English delegates having, through Prof. Hughes, declared in favor of it, though it was erroneously stated in the report of Prof. Dewalque that they preferred "Pre-Cambrian."

The great majority of geologists who have mentioned the subject in their correspondence with your Reporter have expressed a preference for "Archean," but they employ the term in various senses.

Prof. Dana, as the originator of the name, of course should be assumed as in favor of it, though in his letters to your Reporter he does not refer to the matter.

Sir J. W. Dawson prefers the term "Eozoic," and would have it include all the Pre-Cambrian strata.

Dr. S. F. Emmons, following Prof. de Lapparent, would make Archean a subdivision of the Pre-Cambrian strata (Primitive), and with R. D. Irving, Chamberlin, and Walcott, would restrict it to the beds below the Huronian.

A large majority favors the decision of the Congress as to the use of Archean.

For the purpose of ascertaining the opinions of some of the leaders in geological research, the following questions were mailed to them with the request that they would communicate their replies to the writer.

A. Do you agree to the suggestions contained in the Report of the International Committee on Nomenclature (Report of the American Committee on the Work of the Geological Congress,* p. 49 to B. p. 57)? If not,

* At Berlin.

SIGNIFY BY PAGE AND NUMBERED PARAGRAPH THOSE TO WHICH YOU OBJECT, WITH THE ALTERATIONS WHICH YOU WOULD MAKE. PLEASE STATE EXPLICITLY THAT YOU ARE WILLING TO ACCEPT THESE SUGGESTIONS CONTAINED IN THE PART OF THE INTERNATIONAL COMMITTEE'S REPORT REFERRED TO, OR THE RECOMMENDATIONS OF THE CONGRESS, OR BOTH, IF SUCH BE THE FACT.

Of those to whom this question was sent Prof. Irving, Mr. Walcott, Dr. S. F. Emmons, Mr. Thos. Macfarlane, Capt. Dutton, and Prof. Heilprin replied in the categorical manner requested. (Their objections have been tabulated on the next page.)

The following is a condensed statement of the objections to the suggestions contained in the report of the Committee on Nomenclature:

1. The restriction of the word 'formation,' to ideas of origin and not of time, is endorsed by Macfarlane and Dutton, and opposed by Emmons and Walcott, Heilprin and A. Winchell. No others have expressed an opinion on the subject.

2. In common with many geologists here and abroad, Irving, Emmons, Walcott, Macfarlane, Heilprin and Dutton, do not approve of putting 'group' at the top of the classification. Emmons and Walcott prefer 'system,' Macfarlane and A. Winchell prefer 'series,' Dutton and Irving do not specify, but the latter is willing to conform to any of the suggestions as to the three large divisions, provided there is general consent. As stated elsewhere, it is not improbable that a change may be made.

3. Emmons, Walcott and Macfarlane prefer 'group' as the second division, and A. Winchell would have it the third in comprehensiveness.

4. Emmons prefers 'terrane' to 'series' for divisions of the third order.

5. Irving, Walcott and Dutton object to prescribing the names of any divisions subordinate to the last, thinking that these should be left to the geologists of each country. Emmons and Macfarlane object to the word 'stage' for étage. The former suggests nothing in its place, but the latter proposes 'floor' or 'division,' giving preference to the latter.

6. Emmons, Walcott and A. Winchell object to the succession, —order, era, period, epoch, age. The first prefers—era, age, epoch or period,—the others change the places of the last two. Macfar-

STATEMENT IN DETAIL OF CHANGES DESIRED IN PROPOSITIONS OF INTER. COM. (pp. 49–58, REP. AM. COM.).

Pages, paragraphs and clauses of Am. Com.'s Report.	Irving.	Emmons.	Walcott.	Macfarlane.	Dutton.	Heilprin.
49, I, 1	Would prefer for all the divisions down to the third order the terms as used by Major Powell in his communication to the Congress, but would be willing to give them up if there be general consent.	Seems a pity to give up Formation as unit of division.	Prefer to the Formation to designate a single deposit. the unit of geologic nomenclature	I approve of the exclusion of Formation, and think a further improvement would be to confine it to the eruptives.	To use of Formation I agree.	Cannot agree to use of "Formation."
50, I, 2		Prefer "System."	I prefer "System."	Prefer "Series."	I do not concur. It does not seem to me that such a subdivision of strata would conform to the order of nature.	Prefer "Series."
50, I, 3		Prefer "Group."	Prefer "Group."	Prefer "Group."		Prefer "Group."
50, I, 4	Below this, am unwilling to endorse any definite system of nomenclature.	Suggest "Terrane."	No objection, but think the minor divisions should be left to geologists of each country.	5. "Stage" seems not the proper word. "Floor" better, but prefer "Division."		
50, I, 5, 6, 7, 8 and 9		5. Neither "story" nor "stage" represents étage, etc.			See no objection to era for 1st time div.; period for 2d; but below this arbitrary time div. useless.	
51, I, 11, 12 and 13	"	Would suggest Era, Age, Epoch, or Period.	Prefer Era, Age, Period, Epoch.	12. Prefer "Time" to correspond with Series.		
52, VI, VII, VIII	"		No special objection.		Objected to.	
52, IX					Agreed to.	
52, 53, X, XI	XI, c. Particularly objectionable.	XI. Not practicable. Would result in greater confusion than we have now.	XI. a, b, c, d, e, objected to.		X, XI. Objected to.	
53, XII, XIII			XII, XIII. Objected to.		XII. Agreed to.	
54, XIV					Seems to me we may, with advantage, adopt six grand time divisions, viz.: a, Archean; b, Intermed.; c, Paleoz.; d, Mesoz.; e, Cenoz.; f, Quaternary.	
54, XV					Objected to.	
54, 55, a, b, c	Do not believe that any of the proposed divisions can be made for America.					
55, 1, 2, 3.	I dissent entirely.					
56, A	Archean is not Paleozoic, nor do I see any reason for calling it otherwise than Archean, unless we agree to retain the term Laurentian for the great Archean basement so far as America is concerned.		Prefer to use Archean as already mentioned.			

lane prefers 'time' to correspond with 'series' instead of 'epoch,' as preferred by the International Committee. Irving and Dutton are unwilling to endorse any system of nomenclature for divisions below the third.

7. To the International Committee's use of 'rocks,' 'zone,' and 'horizon,' Walcott does not object. Dutton objects. Irving's objection as below division 3 holds.

8. To the restriction of 'depot' to a mass produced during a limited time or space and characterized by petrographical homogeneity, Dutton assents.

9. To the application of univocal names to units of the first order and homophonous terminations to the different orders of units, Dutton and G. M. Dawson object. In the latter subject Irving objects particularly to the termination 'ic.' Emmons, Walcott and Gilbert object to the entire proposition regarding homophony, the latter because it would "render it impossible to name a stratigraphic division without declaring its taxonomic rank. It would infringe the right of reserving opinions."

10. To the exclusion of names taken from petrography such as the division 'chalk,' etc. Dutton agrees and Walcott objects.

11. Walcott objects to the restriction of a name of a place from serving units of two orders, *i.e.*, portlandic series, and portlandian stage, etc.

12. Dutton proposes six grand divisions of the geological scale. *a*, Archean; *b*, an intermediate division to be named; *c*, Paleozoic; *d*, Mesozoic; *e*, Cenozoic; *f*, Quaternary.

13. To the division of the Cretaceous system, the disposition of 'flysch,' and that of the 'rhætic,' Prof. Irving objects that none of these divisions are applicable in American Geology.

14. He dissents, as does A. Winchell, from the division of the now abandoned Crystallophyllian (Archean) group into, 1, Gneiss and Protogine; 2, Crystalline Schists; 3, Phyllites.*

15. Irving and Walcott express a preference for the term Archean, as already mentioned by them, for the lower division of rocks.

16. Mr. Gilbert objects to the provisional scheme of colors proposed for the European map; 1st, that it is not suited to the making of detail maps; and 2d, as a universal scale its great defect is that it makes no provision for the indication of strati-

* All this was rejected or postponed by the last Congress.

graphic systems which do not coincide in beginning and ending with the stratigraphic systems of Europe.

Dr. S. F. Emmons suggests as to colors, three fundamental colors or tones of one general color to be assigned to, 1, crystalline or granitoid; 2, porphyritic or intrusive (which have congealed slowly and under great pressure); and 3, surface flows which have congealed rapidly and under atmospheric pressure. The darker shades to be assigned to the more basic, and the lighter to the more acidic.

Prof. J. D. Dana, Sir J. W. Dawson, Major Powell, Dr. T. Sterry Hunt, Prof. Jos. L. Le Conte, Dr. Emmons, Prof. Geo. H. Williams, Prof. C. H. Hitchcock, Prof. N. H. Winchell and Prof. B. Emerson answer in a more general way. Of these five would accept the decisions if once made, and a sixth would do so down to divisions of the third order.

Of the above suggestions there is no such unanimity as to enable one to reach any opinion as distinctively American. The more important desire seems to be the change of the word Group, from its position as the denomination of the largest division.

Of the others some are of minor importance and some are merely provisional and tentative, the map of Europe being the project selected for testing them.

Others of these more general answers to this question here follow, together with what seemed to be the most important statement of those whose opinions have been just quoted, and which could not for obvious reasons be introduced into the synoptical table.

PROF. J. D. DANA: "If the scheme pp. 49 and beyond were the latest proposition, I might discuss it, but as it is not, I do not feel like saying much without consulting with others. I see in Cappellini's Report of the Geneva meeting in August, 1886, the remark that the French would put 'series' above 'group,' just reversing the scheme of 1885. I find in Renevier's little brochure on the 1885 Berlin meeting that at the Zurich conference, it was proposed to make the *Système Silurique* include No. 4, Cambrian; No. 5, Ordovician; No. 6, Silurian; a good idea, and that this idea will go to the Congress of 1888 from Switzerland." *

* [Prof. Dana will find both these ideas referred to on pp. 51 and 91 respectively of the American Committee's Report on the Congress at Berlin. As to the first, Prof. Dewalque's committee expressly left the decision to the Berlin Con-

SIR J. W. DAWSON would prefer Eozoic to Archean, and adds: "I cannot agree to the various recommendations of the report. Many of them are good, but others are absurd."

The term Crystallophyllian is objectionable, for there are bedded crystalline rocks in all the older formations, and no great division can be said to be exclusively crystalline. The same objection applies with still greater force to the subdivisions 1, 2, 3, on p. 55, since rocks of the kind mentioned are not exclusively characteristic of the Eozoic, and occur in many later groups.

MAJOR POWELL does not understand that the International Congress has reached many definite conclusions except those necessary for the preparation of a map of Europe.

DR. T. STERRY HUNT says: "Many of the suggestions of the International Congress I cannot accept, but I will not specify."

PROF. JOSEPH L. LE CONTE agrees to all the suggestions, but would have preferred some things otherwise.

PROF. ROLAND D. IRVING would be willing, if there is general consent, to use the terms recommended for the grander divisions by the Committee, not under the third order. He objects to the terminations 'ic' in Siluric, etc. He says: "I recognize the necessity for some sort of agreement as to these terms of grander scope, even if they have to be somewhat arbitrarily applied. But to establish any further subdivisions designed to be of any general applicability, serves only to hinder the geologist who is working in a new region."*

DR. S. F. EMMONS would confine the universal divisions to

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gress, which did not decide it (p. 51, iii.). The suggestion of which Prof. Dana speaks as coming from Switzerland, and to be presented at the Congress of 1888, appears to be a proposition of the Belgian Committee (see p. 91).]

This was also left over to the next session by vote of the Berlin Congress.

The name 'Archean,' and the rank 'group,' were agreed to by the Congress. Pending future consideration, Prof. Hughes's proposal to leave the petrographic divisions to the working geologist, and not to assign any chronological value to them, was adopted. These three votes were all that were taken on the Archean Report.

* Presumably Prof. Irving refers here to the establishment of horizons intermediate between those dividing the series from each other, and not to the plan of naming the major and minor divisions when found, on the scale of nomenclature suggested.

the three higher orders, leaving the rest to the different countries. With certain exceptions he finds the suggestions admirable.

MR. CHAS. E. WALCOTT takes numerous exceptions to parts of the report of the International Committees on Nomenclature, as mentioned above.

PROF. GEO. H. WILLIAMS agrees unreservedly to the suggestions of the International Committees and the recommendations of the Congress.

PROF. C. H. HITCHCOCK also is prepared to accept them.

PROF. N. H. WINCHELL adopts the recommendations of International Committees and Congress with the qualification that he would have a series of zones or formations named from their dominant faunal characteristics, adopting some terms now in use, such as 1st fauna or primordial, etc., and while these expressed the chronological parallels throughout the world he would name the rock-masses by other, say geographical terms, letting only the broadest cover large geographic areas, and in all cases allowing new geographic designations to arise in the separate countries for the rock masses where the contents of the specific horizons show such changes as to warrant new names. In short he would prefer a double set of names, one for the paleontological characters, which should be broad enough to extend throughout the world wherever the included faunal dominant types extend, and one for rock formations: the latter to be flexible and applied locally.

MR. THOMAS MACFARLANE agrees in general with the suggestions, but incloses a list of preferences which have been previously given.

PROF. B. K. EMERSON agrees in general with the recommendations of the Committee, and should be willing to accept them.

CAPT. C. E. DUTTON believes that the geologists of the world are pretty well agreed that certain grand divisions of time may be adopted with some margin of uncertainty about their beginnings and their terminations which are of world-wide significance and application, . . . but it does not seem to him that any lower order of time-division than the second (Cretaceous, Carboniferous, etc.), can have more than a local value.

He also incloses the list of amendments to the recommendations of the International Committee on Nomenclature before noticed.

B. Do you favor the division of the Archean Group into a definite number of Systems? If so, give their names and the order of their succession.

Profs. Dana, Jos. L. Le Conte, N. H. Winchell, M. E. Wadsworth, Major Powell, Mr. Hague, Prof. G. H. Williams, Capt. C. E. Dutton, and Prof. Heilprin are not in favor of subdividing the Archean with our present knowledge.

Prof. Hitchcock would divide Archean into Laurentian (Lower, Middle, and Upper), and Huronian, and adds that ultimately we may restrict the Archean to the Laurentian, making sedimentation commence with the Huronian.

Prof. Roland D. Irving would group the Pre-Cambrian rocks into Archean (as yet indivisible), and would call the Keweenaw, Huronian, Grand Cañon, etc., by Prof. Chamberlin's name of "Agnotozoic."

Major Powell would include "Huronian, Keweenaw, Uinta, and Grand Cañon" in this new division.

Mr. Walcott would include "Huronian, Keweenaw, Grand Cañon, Llano" in a division, for the name of which he expresses no preference.

Dr. Emmons suggests that the beds referred to by Irving (those between the Cambrian and Archean), be grouped together as "Proterozoic."*

Prof. Pumpelly would confine the term Archean to the rocks below the top of the Laurentian, and would leave the interval between the top of the Laurentian and the bottom of the Cambrian open for the freest exercise of local classification. For this interval he thinks the term "Agnotozoic" seems unobjectionable.

Prof. Hitchcock suggests *Eobiotic* in place of Eozoic, as it is better to use the Greek word signifying animal life; and also because of a previous use of Eozoic. He thinks it would be better still to say *Eomorphic* in allusion to the fact that the Hu-

* [This name seems preferable to Agnotozoic, both because to select our ignorance of a terrane as a means of identifying it is to select that which all the terranes have most certainly in common; and also because the term Proterozoic is elastic and better adapted to serve as a temporary scaffolding until more of the true history of the earlier rocks becomes known. But Eozoic or Eobiotic seems better than either.—Rep.]

ronian beds are almost the first which show the existence of sedimentation.

DR. G. M. DAWSON thinks our knowledge of the rocks here collectively referred to is not yet sufficient to admit of more definite subdivision.

PROF. A. WINCHELL says "the Archean is an assemblage of clastic rocks taking rank with Paleozoic, Mesozoic, etc. I even suspect that more complete knowledge will show it to possess magnitude and diversification of history equal to all the succeeding formations. It is certainly not permissible to set it down in the rank of a 'system.' It admits of the following systemic divisions:

3. HURONIAN	Ottertail (white) and Thessalon (red) Quartzites. Plummer (conglomeratic) Argillite-Animike. Missisaugui (vitreous) Quartzite.	With associated eruptives. In Canada.
2. MARQUETTIAN	Argillites, chlorite and hydromica schists, quartzites, conglomerates and great beds of hematite, with heavy intercalations of eruptives.	In Michigan. Minnesota. Wisconsin.
1. LAURENTIAN	Crystalline Schists. Gneisses and Granitoid Gneisses.	In Minnesota.

In this exhibit the term 'Marquettian' is used simply for a provisional designation, and it is not intended to propose it as a name of a systemic division. Nor do I here present the equivalences of the subdivisions, nor the evidences on which I rest. I do not here include the so-called 'Keweenawan,' because I incline to the opinion that its equivalents fall within the Paleozoic 'group.'"

SIR J. W. DAWSON, DR. T. STERRY HUNT, DR. SELWYN, MR. THOMAS MACFARLANE, DR. ROBT. BELL, PROF. C. H. HITCHCOCK (provisionally) and DR. G. M. DAWSON favor the retention of Laurentian and Huronian as divisions of the Archean. The latter thinks Huronian more doubtful, as the rocks may prove "relatively local," but would retain it. MR. MACFARLANE adds Taconian to these two as the upper limit of the Archean, but would be willing to substitute for Laurentian, Huronian, and Taconian; Gneissose, Schistose, and Phyllitic. DR. HUNT regards at least six divisions as established, to wit: Laurentian, Norian, Arvonian, Huronian, Montalban, and Taconian and adds that perhaps there should be another division made by dividing the first or Laurentian.

So far as these views can be taken as representing the sentiment of those American geologists who think for themselves, there is

a small majority in favor of attempting no division of the *Archean* at the present time, but inasmuch as some of this majority favor to a greater or less degree the recognition of another division of Pre-Cambrian rocks, and the restriction of the word "Archean" to the lowest division of those rocks, the opinion in favor of accepting some divisions of the *Pre-Cambrian* at the present time is about three to one. It would seem, therefore, to accord as nearly as possible with the views of the majority of American geologists to accept a twofold division of the Pre-Cambrian rocks, of which the lowest, crystalline and not certainly originally stratified, shall be called Archean, and the upper shall take some other name.

It is, of course, understood that the twofold division will not necessarily interfere with a further subdivision of the measures, if our knowledge justify it; nor even with the existence of Norian, Arvonian, Huronian, Montalban, Keweenaw, Animikie, Grand Cañon, Uinta, Llano, or any other divisions which can be proved to the satisfaction of geologists to have more than a local value. In any case, proceeding cautiously in the creation of new divisions will be more likely to result in that unification of theory throughout the world which is the principal object of the Congress.

The Congress on the second day voted, 1st, to call "all the rocks preceding the Paleozoic," "Archean;" 2d, that the "Archean" should be considered a "group." If the suggestion of the Congress be carried out, Archean would become the general term, including others of less extent. But if life in the portion of the Pre-Cambrian measures above the Laurentian be conceded, then one or more of these divisions will contain fossils, and the absence or presence of life will cease to be a characteristic distinguishing the lower grand divisions from each other. It seems to be the underlying, if not always expressed, thought of the majority of American geologists that this ought to be such distinguishing characteristic, and hence arise the various plans for subdividing these rocks.

Since we cannot assign any absolute value to the divisions made for convenience of classification, there is no important difference between making the "Eo—," "Agnoto-" or "Proterozoic" of equal rank with the other groups, or assigning to it a subordinate rank in the group of Pre-Cambrian strata. Its relative position would

be the same, and all that varied would be the guess as to the importance of the time it represented. No geologist will contend that we have the data for settling such questions at the present time. As pointed out by Prof. Dana, the strongest break in the whole Paleozoic column is between the Lower and Upper Silurian; no fact therefore like that just alluded to need stand in the way of the provisional classification of the entire Pre-Cambrian rocks as Archean (voted by the Congress), with two principal divisions.*

Neglecting the unessential elements, such as names, there seems to be a fair agreement among working geologists in favor of giving a name to the Pre-Cambrian; of considering it at present as consisting of at least two parts; of preserving the word Laurentian for its lowest member, and of adopting a word as non-committal as possible for the other.

This preference also seems to be shared by many foreign geologists. Thus the French propose to call the Pre-Cambrian rocks "Primitive," and to divide them into (1) Fundamental Granitoid Gneiss, and (2) Schistose Gneiss and Mica Schists; Amphibolic Gneiss; (3) Cipolin; Chlorito-Schists. The Portuguese proposed to call the lowest division of rocks "Primitive" or "Azoic," which should consist of one system, "Crystallophyllic;" which latter should have but one Series, or Laurentian. Above this the 'Archeic'† System with the Huronian Series is at the base of the Paleozoic. The Roumanian Committee arranges them "Group —Primitive; System—Archeic; Series—Etage, Huronian and Laurentian." To all intents these plans agree with that above which, it was thought, might harmonize the views of American geologists.

By the manner of putting the two questions relating to the Pre-Cambrian rocks at Mr. Firket's suggestion, viz.: "1st. Shall they be called Archean or Primitive? 2d. Shall they constitute a Group or System?" not so much the relative value of these terms, Group or System, as the decision by the Congress whether the Pre-

* See Note 1, p. 184.

† It is appropriate here to call attention to a singular inconsistency in spelling the word 'Archean.' Surely, if the adjectives Καινος and Παλαιος make Cen- and Pale-, Αρχαιος ought to produce Arche-. Prof. Dana in replying to a letter addressed to him on this subject acknowleges the justice of the criticism but says that he adopted the other spelling to avoid misapprehension.

Cambrian formed one of the large units of division, or one of subordinate importance, was asked. But the opinions expressed by the various national committees on the use of these terms having been so various, it seems in order to consider the suggestion of Prof. Cope to abandon altogether the term "Group" as one of the classificatory divisions, and to substitute for it Realm; leaving the word Group free for application to temporary and convenient collocations. Such a change would have many advantages, will probably receive the support of many American Geologists, and perhaps will not encounter any serious opposition in the Congress.

C. Give the horizons of non-conformability in the Archean.

The question of the number of planes of unconformability in the Archean is really a part of the previous one, but was separated for greater clearness, and also because it does not follow that a physical break marks the beginning of a new System.

Sir J. W. Dawson recognizes three breaks in the Eozoic (Pre-Cambrian) as follows: between the Upper Laurentian and Lower Huronian; between the Lower and Upper Huronian; and between the Upper Huronian and Cambrian.

Dr. T. Sterry Hunt recognizes a physical break at least between every two adjoining systems of his classification, and probably one in the Laurentian besides—seven in all, counting the latter and also one between the Taconian and the Cambrian.

Prof. Roland D. Irving recognizes one between the Archean (Laurentian) and the Agnotozoic; one between the Agnotozoic and the Cambrian; and "minor, though still very extensive unconformities between the members of the Agnotozoic themselves."

Prof. Joseph L. Le Conte accepts Irving's two grand unconformities in the Archean (Pre-Cambrian), but does not express an opinion as to the minor breaks.

Prof. M. E. Wadsworth believes that non-conformabilities in the Archean thus far are petrological, not geological, and prove nothing concerning chronological division, as they are local, not general.

DR. SELWYN, DR. EMMONS, PROF. C. H. HITCHCOCK, and MR. THOMAS MACFARLANE are not able to specify any non-conformabilities. PROF. HITCHCOCK adds that he has only the New England rocks in mind.

PROF. N. H. WINCHELL writes:

"As Dana at first defined the Archean, there is a perceptible unconformity at the base of the Huronian, as I published in 1880. (See my Ninth and Tenth Annual Reports, Minnesota Survey.) But as it is limited by Irving and others, making it embrace only Laurentian, I do not know of any unconformity in it, though I presume local unconformities have existed, which now are hid by folding and metamorphism. The unconformity between the Huronian and the Laurentian of Dana's scheme, I have fully verified in the past season. (See my brother's paper in the *American Geologist*, No. 1, vol. i.)"

MR. C. D. WALCOTT applies the word 'Archean' of the question to the Laurentian, and says "as above defined it cannot be divided."

PROF. PUMPELLY has positive personal knowledge of non-conformability between the Laurentian and the "Agnotozoic" at the base of the Keweenawan.

PROF. A. WINCHELL says:

"1. Between Laurentian and Marquettian, there occurs a change in mode of geognostic action. The former rocks are crystalline, the latter normally uncrystalline.

"2. Between Marquettian and Huronian, a stratigraphic unconformability of a decided character."

*PROF. DANA, MAJOR POWELL, PROF. GEO. H. WILLIAMS, PROF. B. K. EMERSON, CAPT. C. E. DUTTON, and PROF. BLAKE do not state their views.

There seems to be a belief, on the part of a large majority of those who have expressed themselves on the subject, that the Pre-Cambrian rocks consist of at least two systems, but they are unwilling at present to concede any but local planes of non-conformability. There seems to be, however, an unexpressed belief, that at least one such plane—at the top of the Laurentian—is destined to be established by future work.

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* Prof. A. Winchell here apparently includes Dr. Hunt's Arvonian, but not with a like definition.

D. Do you approve the plan of subdividing the Archean petrographically, and of omitting corresponding chronological divisions and names?

In the last session of the Congress, after its silent refusal to attempt a division of the Archean, Prof. T. McKenny Hughes proposed that where these rocks occurred the geologist studying them might express their petrological characters, and omit all attempts to give a chronological succession. To this Prof. Renevier, of Switzerland, agreed. This plan was temporarily to take the place of the ordinary classification.

Sir J. W. Dawson thinks that like other formations the Eozoic should be divided stratigraphically and the qualities of its rocks should be used merely as characterizing subordinate series. This is especially necessary, he thinks, in a group where we may have in one series crystalline and non-crystalline rocks, or rocks so different as gneisses, quartzites, and limestones.

Dr. Selwyn thinks the Archean should be dealt with petrographically like other systems.

Prof. J. L. Le Conte approves the plan for local distinctions.

Prof. Irving holds this view, provided the plan be not extended beyond local description.

Mr. Arnold Hague thinks the whole tendency of modern research in this direction, but sharp lines cannot be drawn.

Prof. G. H. Williams thinks that petrographical classification is the only safe one, aside from the two-fold division of Laurentian and Huronian.*

Prof. C. H. Hitchcock would use petrological, or chronological, or geographical division as might be most convenient.

Mr. T. Macfarlane approves of it, but would rather leave it to the national committees.

Prof. B. K. Emerson would use petrological division only for local and temporary use.

Dr. Robert Bell approves of it.

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* In a late note, Prof. G. H. Williams modifies his view, first given, of the advisability of this two-fold division, and prefers to omit it for the present.—Rep.

PROF. J. D. DANA says: "Petrographic maps are valuable. Petrographic divisions are all conveyed by such maps as far as they are important."

DR. T. STERRY HUNT thinks that the distinctions ought to be at once petrographical and chronological.

PROF. N. H. WINCHELL objects that petrographers are not yet sufficiently agreed on the meaning of their terms.

PROF. WADSWORTH thinks there is too little knowledge of the true petrography of the Archean.

DR. EMMONS, PROF. BLAKE, CAPT. C. E. DUTTON and PROF. A. WINCHELL disapprove of this plan.

PROF. PUMPELLY approves of it only for local distinction.

DR. G. M. DAWSON thus answers the question: "No, except as a local expedient, guardedly applied, in the absence of stratigraphical evidences. The *Laurentian* may, however, prove to be an exception to all other formations in this respect."

The weight of the opinions seems to incline towards using the method locally without attempting to establish definite horizons over remote areas by lithological distinctions.

E. SHOULD THE ERUPTIVES OCCURRING IN THE ARCHEAN ROCKS BE CLASSIFIED WITH THE LATTER OR SEPARATELY?

The prevailing opinion that many of the Archean rocks, which have been heretofore looked upon as sedimentary, are altered igneous rocks, and that it is impossible at the present time to distinguish the sedimentary from the pseudo-sedimentary, suggested the above question which was brought up incidentally in debate at Berlin.

PROF. J. D. DANA thinks that eruptives of each age should be colored with some distinguishing shade of the color of that age.

SIR J. W. DAWSON in answer to this question writes "some bedded aqueo-igneous strata."

DR. T. STERRY HUNT says the various eruptive rocks, whether plutonic or pseudo-plutonic, should be omitted in classifying the Archean.

DR. SELWYN thinks that it depends upon whether the age of said eruptives can be, or cannot be, determined, and which are eruptives, which irruptives, and which simply metamorphic.

PROF. J. L. LE CONTE answers that "to classify the eruptives occurring in the Archean with the Archean as of Archean age would, it seems to me, lead often to errors, as so much Archean is exposed only by erosion and the eruptives may be much younger." In fact, he thinks we must study eruptives as eruptives only—until we understand them thoroughly, and then we may or may not be able to correlate kinds with age. At present he does not believe in any classification of eruptives by age.

PROF. ROLAND D. IRVING recalls that there are two classes of eruptives found in the Archean: one erupted in Archean time, and the other subsequently. Sometimes these classes can be distinguished, but as a rule they cannot. In any sort of a general map of a region he does not think that the Archean eruptives should be distinguished from the rest of the Archean. In local mapping, however, when the eruptive origin of certain granitic areas has been clearly established, then he would map them separately. Similarly he would map special areas of basic eruptives which have been clearly proved to be such. But in both these cases he would map the rocks under their special names—such as "granite," "diabase," or whatever it might be; and not simply as "eruptive;" for a considerable portion of the Archean can, he thinks, be clearly shown to be of eruptive origin. That is, schistose structure has been superinduced upon both basic and acid eruptives. As to the origin of a still larger proportion of the schistose Archean, he thinks we know nothing. Therefore, to set forth only portions of the Archean as "eruptive," without specifying the kind of rock, raises the presumption that the remainder is non-eruptive—a presumption that would certainly be, in a measure, false.

MR. ARNOLD HAGUE is of the opinion that rocks found in the Archean, the eruptive nature of which is unquestioned, should be classed independently of the sedimentary and metamorphosed strata.

DR. S. F. EMMONS thinks that the Archean eruptives should be treated in the same manner as those of other geological systems. It is not always possible to determine whether they were erupted in Pre-Cambrian times or not; and even if it were, the color scale is not extended enough to furnish distinct colors for the eruptives of each system.

PROF. GEORGE H. WILLIAMS would prefer to classify the eruptives of the Archean with their including rocks.

PROF. W. P. BLAKE would have eruptives separately classed.

PROF. C. H. HITCHCOCK holds that eruptives in the Archean should be separated from the ordinary foliated beds on maps and in descriptions. He adds, in a note, "I regard the 'Norian' system of Hunt, and what he calls the 'Arvonian,' in America, as eruptive masses. They should be mapped and described as eruptives and not as stratified systems."

PROF. N. H. WINCHELL thinks that the eruptives occurring in the Archean should not be considered a part of the stratigraphic scheme of classification, but they should be named as a part of the classification. They seem to be local, irregular and capricious in their distribution. He would prefer some classification devoted entirely to them (and for them), but allowed for in the stratigraphic column when they are found at any horizon.

MR. THOMAS MACFARLANE holds that the Archean eruptives, wherever found, should be classified separately.

PROF. M. E. WADSWORTH answers the question: "No; they are too intimately mingled with the stratified rocks; and, as yet, we do not know what are eruptive and what are sedimentary."

CAPT. C. E. DUTTON says: "I see no reason for treating the eruptive rocks of the Archean any differently from those of other ages." This means to answer the question, "No."

PROF. HEILPRIN: The eruptive rocks of the period should be classified apart from the Archean rocks proper.

PROF. PUMPELLY: "Only when their eruptive origin is clear and of Archean age, and even then, for the present, I would follow the old method of relegating them to a separate graphic scheme for eruptives."

DR. G. M. DAWSON: "Separately as in other formations."

PROF. A. WINCHELL says: "They must first be classified petrographically, in consequence of the difficulty of determining their relative age. But the search for their chronologic succession should never be intermitted, and their relations to the beds which they intersect should always be recorded."

To sum up the opinions expressed:

PROF. DANA, SIR J. W. DAWSON, and PROF. GEORGE H. WILLIAMS (the first two in map-making and in the special case of foliated eruptives respectively; the last unreservedly), are the

only three who have expressed themselves in favor of classing eruptives with the Archean under any conditions. DR. HUNT, DR. SELWYN, PROF. JOS. L. LE CONTE, PROF. R. D. IRVING, MR. ARNOLD HAGUE, DR. S. F. EMMONS, PROF. W. P. BLAKE, PROF. C. H. HITCHCOCK, PROF. N. H. WINCHELL, MR. THOS. MACFARLANE, PROF. HEILPRIN, PROF. M. E. WADSWORTH, CAPT. DUTTON and PROF. A. WINCHELL are opposed to classifying the eruptives with their including strata.

F. WHICH, IF ANY, OF THE FOLLOWING TERMS IS APPLICABLE IN AMERICAN GEOLOGY, AND HOW APPLIED? HEBRIDIAN, DIMETIAN, ARVONIAN ?*

Without attempting to decide whether or not lithological descriptions enable one to classify two igneous rocks in different parts of the world in the same system, the description of the occurrence of the English Pre-Cambrian rocks, in Appendix II, of this Report, taken from the report of the English Committee to the Berlin Congress, is given in order to facilitate a comparison between these rocks and our own.

In answer to the question, SIR J. W. DAWSON says: "There are good European equivalents for our Laurentian and Huronian."

PROF. J. L. LE CONTE does not believe that any of these names can, in the present condition of knowledge, be safely applied to American rocks.

PROF. ROLAND D. IRVING does not think that any one of these terms should be used in American geology.

DR. S. F. EMMONS does not think the use of any of these terms advisable.

PROF. C. H. HITCHCOCK thinks that the European terms of "Hebridian," "Dimetian," "Arvonian," and "Pebidian," should be carefully excluded from American geology. If priority of suggestion is to be observed, the Europeans must borrow our names for these rock-masses.†

PROF. N. H. WINCHELL says: "I do not know anything about the foreign terms, except that I am satisfied that the Arvonian is a metamorphic condition of some of the sediments (perhaps of

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* See Note 2, p. 187.

† There is an implication here that the rock-masses on both sides of the Atlantic can be correlated.

Archean and perhaps of Carboniferous age, the latter, as it seems to me, in the vicinity of Boston)."

PROF. M. E. WADSWORTH would employ in American geology none of the terms mentioned.

CAPT. C. E. DUTTON does not think that we can as yet identify any American rocks as the equivalents of the so-called Hebridian, Dimetian, Arvonian, and Pebidian, and, therefore, the use of such terms would be mere guesswork.

PROF. PUMPELLY: "Do not need them on this side of the Atlantic."

PROF. A. WINCHELL is not aware of any recognized use of these terms, and does not know the petrographic or stratigraphic equivalence of Arvonian, which has been proposed to stand in the gap where he has placed Marquettian.

It thus appears that all but two geologists who have expressed an opinion, are opposed to the use of these terms in American geology. One of these two thinks that American names should have priority, and the other would retain Arvonian for the formation immediately preceding the Huronian, and Hebridian for Lower Laurentian.

The opinion is about ten to one, so far as it has been expressed, against the use of any of these terms for our native measures.

G. ARE THERE CRYSTALLINE ROCKS IN AND AFTER THE PALEOZOIC, LITHOLOGICALLY INDISTINGUISHABLE FROM THOSE OF THE ARCHEAN?

It is a moot point among some of the foremost geologists in all countries whether a combination of structure and mineralogical constitution, in other words, qualities determinable by the eye, have, or ever will have a significance of the same kind as the remains which permit us to judge of the stages of life which existed in successive systems. Some who deny the first part of the proposition admit the second. The question is not a new one, but one of those ever recurring. By the painstaking citations in the work of Profs. Whitney and Wadsworth, it is shown that almost every geologist who has written on the subject of the crystalline rocks, has at one time or another sought to correlate masses of

them at a distance from each other, or to adduce evidence of them by lithological resemblances.*

In point of fact, if it be once established that there are no characteristics of the oldest known crystalline rocks by which they may be distinguished from eruptive masses of any subsequent period; that the underlying granite floor which was the first to be solidified, is liable to be softened and pushed upwards through flaws in the earth's crust, and when newly established becomes indistinguishable from the original mass: the crystalline rocks will excite an interest very subordinate to the sedimentary, and can give but litle aid to the solution of the questions of the later evolution of the planet.

PROF. J. D. DANA answers: "There are many crystalline rocks in and after the Paleozoic which are indistinguishable from that of the Archean."

SIR J. W. DAWSON says: "Yes, there are such, but they are exceptional, whereas in the Archean they are typical."

MAJOR J. W. POWELL is of opinion that the question is not to be settled by a convention of geologists, but by investigation.

Dr. T. STERRY HUNT denies that there are any indigenous silicated rocks in and after the Paleozoic which are indistinguishable from the Archean.

PROF. JOS. L. LE CONTE says: "I am not able to distinguish some crystallines of later age from some of Archean age, but I do not say that others cannot."

PROF. ROLAND D. IRVING says: "I suppose that the only answer I can give to this is, that I do not know and I do not believe that any one else *knows*. Having said this, I will give my *notions*.

"Eruptives, of course, should be set aside. They may be similar in the Archean and Post-Archean formations. Outside of unmistakable eruptives my own experience—and my own experience leads me wholly that way—is that while there are rocks which have been altered and have acquired a semi-crystalline character, *e.g.*, some mica-schists and quartzites, among the Post-Archean formations, counting now the Huronian as Post-Archean—there are some true Archean rocks, chiefly the true banded gneiss, which do not occur above the Archean. But in saying this I

* These authors themselves do it on p. 522 of their *Azoic System*, where they allude to the lithological character of certain rocks as belonging to the Azoic.

should not be taken as endorsing Hunt's views that all crystallines are pre-Paleozoic—as I know directly from examining the samples Hunt would call crystalline rocks, which are under the microscope plainly fragmental, having only a superinduced crystalline structure, *e.g.*, *some* mica-schists. These, I think, are undoubtedly often post-Archean. In other words, I think the truth lies between the hypotheses of geologists. Many semicrystallines which by Hunt and his followers would be looked on as Archean, largely perhaps because they are crystalline, are Post-Archean, or even Post-Paleozoic; nevertheless they differ from the great Archean gneiss which is simulated not reproduced above the Archean. But, as I say, these are my notions only."

Dr. S. F. Emmons says: "It is very probable that rocks may occur in the later formations which by themselves, or in hand specimens, would be indistinguishable from the crystalline rocks of the Archean."

Prof. C. H. Hitchcock answers: "Yes; because the Archean conditions are repeated locally."

Prof. N. H. Winchell does not know, but thinks that some of the later crystalline rocks have been confounded by geologists with rocks of the Archean age. They may, however, be distinguishable when carefully studied.

Prof. M. E. Wadsworth answers: "Yes."

Prof. B. K. Emerson answers: "Yes."

Capt. C. E. Dutton replies: "The answer to this question should, it seems to me, depend somewhat upon what constitutes a distinction. If we draw distinctions fine enough we can distinguish petrographically two fragments of the same boulder. I know of Paleozoic rocks which I think ought to be called schists, and which have a great deal in common with Archean rocks; but if anybody is determined to find a distinction, he can easily do so. Broadly speaking, however, all the Archean rocks I have met with have a character of their own, and, however nearly they may be approached by later formations, distinctions can easily be made."

Prof. Pumpelly: "There are crystalline rocks in the Paleozoic which have a strongly marked Archean habitus; but I think there are some Laurentian rocks of which the characteristics are not repeated in later times."

Prof. A. Winchell: "Yes."

PROFS. DANA, LE CONTE, HITCHCOCK, WADSWORTH, EMERSON, SIR WILLIAM DAWSON, DR. EMMONS and PROF. A. WINCHELL think there are crystalline rocks in the Paleozoic and later which they cannot distinguish from some in the Archean.

DR. HUNT, PROF. N. H. WINCHELL, and CAPT. C. E. DUTTON believe that, broadly speaking, there are none when carefully studied, and Prof. Irving inclines to this belief without dogmatically asserting it.

There is no such unanimity of belief here as would warrant the statement of either view as that representing American opinion.

H. ARE THERE ANY CRYSTALLINE ROCKS IN THE ARCHEAN WHICH DO NOT OCCUR LATER?

This question is complementary of the last.

PROF. J. D. DANA says: "Chondroditic limestone is, I now think, of Archean only, except what is eruptive, and others are also distinctive, but not gneiss or mica-schist."

SIR J. W. DAWSON remarks: "Some varieties of orthoclase gneiss I have not seen in any later formation."

DR. HUNT: "The indigenous rocks of the Archean are not repeated later."

PROF. LE CONTE does not believe we can pronounce with certainty, though often with probability.

PROF. IRVING includes this question with the last. The true banded gneiss of the Archean is simulated, not repeated.

DR. S. F. EMMONS thinks, that while the Archean rocks, as a whole, are distinct from those of later formations, he would not venture to say that individual representatives of any of these varieties may not be locally developed in later formations.

PROF. HITCHCOCK is of the opinion that we probably do not have the hypersthene, labradorite, olivine, and corundum associations outside of the Laurentian in any large amount. Other minerals, also, are confined to the Laurentian.

PROF. WADSWORTH knows of no crystalline rocks in the Archean which do not occur later.

PROF. EMERSON thinks "there is rather a difference of habit, *e.g.*, extremely coarse and perfect crystallization."

CAPT. DUTTON answers this question, together with the last,

that, "Broadly speaking, all the Archean rocks I have met with have a character of their own, and however nearly they may be approached by late formations, distinctions can easily be made."

PROF. PUMPELLY thinks there are some.

PROF. A. WINCHELL: "Probably not; but I do not speak on this subject with adequate knowledge."

PROF. DANA, SIR W. DAWSON, DR. HUNT, PROF. IRVING, PROF. HITCHCOCK, PROF. EMERSON, and CAPT. DUTTON hold more or less strongly to the view that there are crystalline rocks in the Archean which are not repeated later.

PROF. WADSWORTH is alone in pronouncing distinctly that he knows of no crystalline rocks in the Archean which do not occur later; PROF. A. WINCHELL thinks it unlikely that there are any; PROF. LE CONTE and DR. EMMONS, while recognizing a general common character to the crystallines of the Archean, are not willing to commit themselves to the view that this character is never repeated later.

It would seem, nevertheless, that the bias of sentiment was decidedly towards the affirmative of the proposition.

I. IS MINERAL CONSTITUTION INDICATIVE OF GEOLOGICAL AGE?

Most of the replies to this are so cautious that it is difficult to extract from them an unqualified opinion.

PROF. DANA says: "It is *after the demonstration is complete that the rock does not occur in any other age or period.*" [The italicized words are made so by the Reporter. Reading this reply in the light of Prof. Dana's reply to the last question, it would seem to mean that there is at present a limited number of crystalline rocks which have thus far been proved to exist only in certain ages and periods, and which are therefore characteristic of such ages and periods. Furthermore, the list of them can be extended when other rocks are as thoroughly known.—REP.]

SIR J. W. DAWSON answers: "Locally and with some limitations, except in the Lower and Middle Laurentian, which, so far as my experience goes, are the same everywhere." [Therefore, *generally* as to these. This makes the substance of this reply similar to that of Prof. Dana.—REP.]

DR. HUNT says: "The mineral composition of the indigenous crystalline rocks is determined by geological age."

PROF. LE CONTE thinks that it is *a priori* probable, but he does not believe that it is a safe guide in the present condition of our knowledge.

PROF. IRVING thinks, not further than he has indicated under Question G.—[*i.e.*, that the post-Paleozoic crystallines differ from the great Archean gneiss, which is simulated, but not reproduced—and then only doubtfully.]

DR. EMMONS thinks, not of absolute age, though it may serve as an indication of relative age.

MR. WALCOTT answers: "Not in my experience."

PROF. GEO. H. WILLIAMS says: "I do not believe, except in a broad way, that petrographical character in the crystalline rocks is a safe guide to their geological age."

PROF. HITCHCOCK says: "I am disposed to believe that we shall be able to use mineral constitution as defining the different parts of the Archean. The facts are yet to be made out, but Sterry Hunt has made, lately, many suggestions that cannot be lightly set aside. We cannot, however, pick out a particular mineral like Andalusite and make it characteristic of a horizon, as Paradoxides is of the older Cambrian."

PROF. N. H. WINCHELL says: "I think I can identify any Minnesota Archean terrane by a hand-sample that may be presented to me, and I think there is much more reliance to be placed on mineral constancy and association with other minerals, in the matter of determining Archean stratigraphy, than has been allowed (as by Prof. Dana) in recent years."

PROF. WADSWORTH answers decidedly: "No."

PROF. EMERSON answers, "No," in general. Only within limited areas.

CAPT. DUTTON says: "As far as my experience goes, Archean rocks have characters which seem to be distinctive, and which raise a presumption in favor of the view that this distinction is to be found partly in mineralogic characters. But I do not think we have sufficiently investigated the subject to enable any one to say with certainty that this is so, and at the same time point out precisely wherein this distinction consists. As regards all later strata than Archean, I do not believe that any valid mineralogic distinctions can be found. I have seen Middle Cambrian beds which the very elect could not distinguish lithologically from Green River Tertiaries."

PROF. PUMPELLY: "In the present state of our knowledge, I should say only locally."

PROF. A. WINCHELL: "Generally, no; but a few minerals are restricted to particular ages."

In reviewing these replies, it will be observed that while all are guarded and qualified, they evince a stronger tendency towards the main proposition than many recent writings would seem to indicate. DR. HUNT asserts the general principle pure and simple. SIR WILLIAM DAWSON, PROF. IRVING, and CAPT. DUTTON claim it for the Lower and Middle Laurentian rocks, and the former also "locally" (which is often an embryo *generally*) elsewhere. PROFS. LE CONTE and HITCHCOCK think that one day it may be established, though it has not yet been. DR. EMMONS restricts it to relative age, which presumes a value of mineral constitution in determining age, though a restricted one. PROF. N. H. WINCHELL admits it of the rocks of Minnesota, and it is fair to presume that, with equal facilities for observation and the necessary time, this area might be indefinitely extended. PROF. EMERSON admits it of limited areas, and PROF. A. WINCHELL of certain rocks in which occur a few specified minerals. Even PROF. DANA, who has been regarded as the chief opponent of the unqualified statement that minerals were the fossils of crystalline rocks, seems clearly to go as far as Dawson, Irving, and Dutton, for, in a letter on another matter to your Reporter, he says: "My work has, I believe, proved that the lithological canon is a most unsafe guide to true stratigraphical or chronological distinctions. Still, you see in my paper,* that I recognize some rocks as in all probability *exclusively Archean*, such as chondroditic rocks, those containing Zircon abundantly, Zircon syenite, and related rocks of gneissic structure, and rocks containing scapolite, some kinds of augitic rocks. Yet I think the conclusion should have the proviso over it 'until proved erroneous.' The occurrence of chondrodite in Vesuvian throat-clearings is nothing against it, because the throat of the volcano may descend to an Archean chondroditic limestone, and the materials may be derived thence for the new crystallization. On the other hand, gneiss and other schists are among Archean rocks, as they may

* Taconic Rocks and Stratigraphy, with a geological map of the Taconic Regions, by Jas. D. Dana, *Am. Jour. Sci.* for April, 1887, p. 270, and May, 1887 p. 393.

be among the metamorphic rocks of later times. You thus see that I have no scheme of my own to advocate. I advocate only the general principle that the science accept what is proved, and allow the rest to remain in doubt until doubts are removed; that a geological map should not call crystalline schists Archean without first definite evidence that they are Pre-Cambrian, etc."

The plain interpretation of this is, that, after a sufficient amount of work has been done on the geological column to enable one to express any opinion at all as to what the various groups, systems, and series show, it is permissible to state, if such be the result of examination, that this or that group, system, or series contains certain rocks found in no other. Provided, that this be considered, as all results of inductive science must be, a working hypothesis or theory ready to be promptly abandoned as soon as the first fact inconsistent with it be ascertained.

Limited and qualified as above, then, the proposition contained in the question under review has the support of Profs. Dana, N. H. Winchell, Irving, Le Conte, Emerson, Hitchcock, Sir William Dawson and A. Winchell, Capt. Dutton, Drs. Hunt and Emmons (eleven of those asked).

MR. WALCOTT and PROF. WADSWORTH reject it absolutely.

PROF. GEO. H. WILLIAMS rejects it with a certain reservation for its employment "in a broad way."

More than three-fourths of those who express opinions at all, while they do not accept it without many restrictions, refuse to reject it entirely: and leave it to the future.

J. ARE THE LOWER STRATIFIED CRYSTALLINES (1.) OF AQUEOUS ORIGIN METAMORPHOSED PARTLY OR WHOLLY BY IGNEOUS ACTION; OR (2.) OF IGNEOUS ORIGIN METAMORPHOSED IN PART OR IN WHOLE BY SUBSEQUENT AGENCIES; OR (3.) SOMETIMES ONE AND SOMETIMES THE OTHER?*

PROF. DANA holds that there is no general rule. Each rock should have its origin and nature ascertained by special study.

SIR J. W. DAWSON thinks it would require a treatise in explanation.

DR. HUNT says: "The lower stratified crystalline rocks are indigenous rocks of aqueous or crenitic origin and not metamorphic in the Huttonian sense."

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* As sent out this question read "partly" for "sometimes."—REP.

PROF. LE CONTE thinks the lower stratified crystalline rocks are *mostly* aqueous, metamorphosed by heat and water. But recent investigations have shown that igneous rocks may take on schistose form by pressure and shearing. So that it is often (difficult) to distinguish between the two kinds.

PROF. IRVING says: "It is hard to answer the question as put. (*a.*) The great Archean gneiss is of wholly doubtful origin—the appearance being more that of an igneous origin than anything else—but I do not hold this. (*b.*) Many Archean schists, etc., are demonstrably altered eruptives. (*c.*) The true Huronian rocks are mainly sedimentary (*e.g.* quartzites, graywackes, etc.). (*d.*) Some of the Archean (pre-Huronian) rocks are very probably volcanic fragmentals, etc."

DR. S. F. EMMONS says: "(1.) No. (2.) I am inclined to regard them as of aqueo-igneous origin, that is, that they were not absolutely amorphous sediments like those of later formations, and that the subsequent pressure combined with aqueous metamorphism produced or intensified bedding, and caused a certain amount of change and re-arrangement of the mineral constituents."

MR. WALCOTT answers: "As far as my field observations have extended, the lower stratified crystalline rocks are largely of aqueous origin metamorphosed by subsequent agencies. In some instances, large deposits are of igneous origin, inter-bedded and inter-stratified in the strata of sedimentary origin."

PROF. GEORGE H. WILLIAMS replies: "I think that the oldest crystalline schists are in part sedimentary and in part eruptive, although the conditions under which both were formed must have been very different from what they are at present. I consider both classes to have been profoundly metamorphosed, and I think that the same metamorphosing agencies may have produced rocks nearly identical from such masses as were originally very different, in case their chemical composition was much alike."

PROF. C. H. HITCHCOCK is willing to accept Dr. Hunt's crenitic hypothesis long enough to answer (1,) (2) *and* (3.)*

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* It might be inferred from this, as (3) was intended to mean *sometimes* one and *sometimes* the other, and to be equivalent to (1) and (2), but actually said "*partly* one and *partly* the other," that Prof. Hitchcock means sometimes of aqueo-igneous, sometimes of igneo-metamorphosed and sometimes both, but the reporter interprets it without the latter clause.—Reporter.

PROF. N. H. WINCHELL says: "Partly one and partly the other." [*i.e.* (3.)] I can give examples if time and situation demanded.

PROF. WADSWORTH says: "All these conditions occur, but the third is the more common."

CAPT. DUTTON does not believe this question can be answered in the present stage of geologic knowledge.

PROF. PUMPELLY: "I am disposed to consider them to a large extent as metamorphosed sediments which, under some conditions, have been extruded and thus become eruptive:" that is, he believes the part of the question marked (1) correct.

PROF. A. WINCHELL: "Wide observation and study have settled me pretty firmly in the conviction that nearly all of our crystalline bedded rocks were originally sedimentary. I have no doubt also, that most granitoid rocks were originally sedimentary. But this is not to deny that many granites had an eruptive origin, or that in many eruptives a bedded structure has been superinduced by mechanical stresses."

A fair interpretation of the replies of Profs. Dana, Le Conte, Irving, Walcott, Hitchcock, N. H. Winchell, Wadsworth and Emerson (8), favors the view that the lower crystalline rocks consist partly of those which were originally sedimentary, partly of those which were originally igneous, each class being more or less metamorphosed later.

DR. HUNT and DR. EMMONS regard these rocks otherwise, the former as aqueous or crinetic and indigenous, the latter as aqueo-igneous, and not a deposit of amorphous sediments like those of later formations.

A very strong preponderance lean to the view that either of several kinds of origin may be ascribed to the lower crystalline rocks, depending upon the particular case—the sedimentary, the igneous, or the aqueo-igneous.

K. ARE THERE EVIDENCES OF LIFE IN THE ARCHEAN? IF SO, WHERE AND WHAT?

PROF. DANA, in his Manual of Geology, 2d edition, p. 189, says: "There can be little doubt that Rhizopods existed in Archean time," but he does not give his reason for thinking so, nor state whether they possibly existed in the Laurentian period.

SIR J. W. DAWSON answers: "There are abundant evidences of plant and animal life as early as the Middle Laurentian; but nothing definite as yet except Eozoon and a few other forms."

DR. HUNT: "Indirect evidences of organic life are the graphite and metallic sulphides found from the Laurentian upwards. Direct evidences are also found in fossil forms."

PROF. LE CONTE: "I believe there are.—(1.) *Graphite* is probably of organic origin. (2.) Beds of iron ore are presumptive evidence of existence of organic matter. (3.) The existence of limestone is also possible evidence of same."

PROF. IRVING: "Below the Huronian, doubtful; in the Huronian, certain evidences of life."

DR. EMMONS: "No."

PROF. GEO. H. WILLIAMS: "I know of no certain traces of life in the Archean, least of all the Eozoon."

PROF. C. H. HITCHCOCK: "I will give up all signs of life in the Archean, unless it be the argument from iron ore in favor of vegetation. Yet it was no place for plants in the Laurentian."

PROF. N. H. WINCHELL: "I do not believe in the organic nature of Eozoon, but there are evidences of organic nature in the Animikie, viz.: forms of irregular shape imprinted on the slates, as if of sea-plants, and a large per cent. of carbon in the form of graphite. I do not myself know of any limestone in the Archean. None have been found in Minnesota except what may be of chemical origin."

PROF. WADSWORTH: "No, I do not think any have been established."

PROF. EMERSON answers "Yes," as to the evidences of organic life, but he does not specify 'where' or 'what.'

PROF. PUMPELLY: "Nothing in the Laurentian except calcite, graphite, and iron-ore are such evidences," *i.e.*, "Yes."

PROF. A. WINCHELL: "I agree with those who think beds of graphite and iron-ore, as well as bituminous gneisses, are evidences of organic, probably vegetable life. It is to be presumed, also, that beds of Archean limestone sustained some dependence on the influence of animal life."

Of those who have answered or whose views are published, PROFS. DANA, LE CONTE, IRVING, EMERSON, N. H. WINCHELL, A. WINCHELL, PUMPELLY, SIR J. W. DAWSON, DR. HUNT and MR. WALCOTT (10), believe (some on one ground and

some on another), that in part of the Archean (Pre-Cambrian) there exist evidences of former organic life.

PROF. HITCHCOCK thinks that there are evidences of life after the Laurentian, but not within it.

DR. EMMONS and Profs. WHITNEY and WADSWORTH do not think there are such evidences. PROF. N. H. WINCHELL mentions such evidences only in the Animikie.

There is, in spite of this, a majority of your Reporter's correspondents which takes the ground that there are such evidences.

L. IN YOUR OPINION IS EOZOON CANADENSE OF ORGANIC ORIGIN?

PROF. DANA: "I think not."

SIR J. W. DAWSON: "Yes."

DR. HUNT: "Yes."

PROF. LE CONTE: "Doubt it. Have no independent opinion on the subject."

PROF. IRVING: "No. Inorganic."

DR. EMMONS: "No."

MR. WALCOTT: "Yes, probably."

PROF. GEO. H. WILLIAMS: "No."

PROF. HITCHCOCK: "No."

PROF. N. H. WINCHELL: "No."

PROF. WADSWORTH: "No. It has been proved to be geologically impossible that it is organic."

PROF. EMERSON: "No."

PROF. PUMPELLY: "No. Seems to me of metasomatic origin in every section I have studied."

PROF. A. WINCHELL: "Not being an original authority, I have felt disposed to rest on the opinions of experts in the lower forms of animal life, rather than on those of mineralogists and petrographic geologists. I have therefore regarded *Eozoön* as animal in nature."

DAWSON, HUNT, WALCOTT and A. WINCHELL are for the affirmative, and DANA, LE CONTE, IRVING, EMMONS, G. H. WILLIAMS, HITCHCOCK, N. H. WINCHELL, WADSWORTH, EMERSON and PUMPELLY for the negative.

LL. Do you approve the European Map Committee's (Prof. Lossen's) system of coloring and classifying the eruptives?

Major Powell answers: "No."

Dr. Hunt says: "Lossen's scheme for classifying eruptive rocks is defective: first, because it includes many rocks which are not plutonic; and second, because it does not distinguish between true plutonic rocks and those which are endogenous or are pseudo-plutonic, that is to say are softened and displaced crenitic masses."

Prof. Le Conte: "I think any well-recognized scheme of colors is better than the present chaos. I like the scheme proposed by the International Congress. As to classification I don't like the term *melaphyre.* It is too indefinite."

Prof. Irving: "I am not able now to refer to this classification, but as I recollect I did not like it."

Dr. Emmons: "No." (In a previous letter, Dr. Emmons says on the subject of eruptive rocks: "Whatever the colors may be, I think it would be entirely futile for the Congress to reconcile any system with the widely variant names employed by different petrographers of the present day, and this, in the provisional system adopted for the maps of Europe, seems to have been partially recognized."

"This system, however, seems to me a purely arbitrary one, founded on no natural law, except as regards 'Present Eruptives.' But who can determine beyond a doubt whether a recent lava is Quaternary or Pre-Quaternary, or why shall we distinguish practically identical rocks by separate colors, because one happens to be eruptive before and the other after an imaginary period of time? It moreover seems of doubtful advisability to attribute the importance of being one of the seven great divisions of eruptive rocks to a material like serpentine, which is *always* the product of alteration of some other rocks or mineral, and probably quite as often of sedimentary as of eruptive rocks or minerals."

"I would suggest three fundamental colors, or distinct tones of a general color, be assigned to eruptive rocks. Of these, one should be given to crystalline or granitoid rocks, one to intrusive or porphyritic rocks, which have congealed slowly and under great pressure; one to surface-flows, or rocks that have congealed

on the surface under only atmospheric pressure, and which hence contain considerable isotropic or glassy material. In each of these divisions the local geologist can subdivide to suit the needs of his particular map, by variation in the given color or tone, taking care to assign in general the darker shades to the more basic rocks, the lighter ones to the more acidic."

PROF. GEO. H. WILLIAMS: "Yes."

PROF. HITCHCOCK: "Yes."

PROF. N. H. WINCHELL: "I think there is too great a similarity in the first three colors, but as they may not be generally needed on the same map, they may not occasion any confusion."

MR. THOMAS MACFARLANE: "I would like to see an additional and darker color used to denote the modern basic eruptions, leaving the color 'eruptions actuelles' to represent modern acidic lavas. The other six colors might be used with a little precision in the following way: The color representing Granite, Syenite, etc., I would consider as applicable to the acidic eruptions of primitive and primary time; while the Serpentine color would denote besides the basic eruptions, Urgrünstein, Norite, Gabbro, etc. Similarly, the colors for 'porphyres' and 'melaphyres' would represent respectively the acidic and basic eruptions of the Paleozoic and Mesozoic eras. Lastly, the colors of the Trachytes, Phonolites, etc., and for 'Basalts, Dolerites,' etc., would denote the acidic and basic eruptions respectively of Tertiary and pre-historic time. I here introduce a table, which is an attempt of mine to elaborate the one given on p. 105 of your report,* and to find room for as many as possible of the names of groups, systems, etc., which are now competing for recognition." (See next page.)

PROF. EMERSON: "Yes."

PROF. A. WINCHELL: "On the whole, yes, but do not favor a division designated 'Serpentine.'"

Of the above replies those of LE CONTE, WILLIAMS, HITCHCOCK, N. H. WINCHELL (with a minor objection not insisted on), PROF. EMERSON and A. WINCHELL (one point excepted), approve Lossen's system. POWELL, HUNT, IRVING, EMMONS, and MACFARLANE do not. DAWSON, DANA, WADSWORTH, and DUTTON express no opinion.

It is quite evident that the scheme which has been adopted by the map-committee for the purpose of bringing out the map of

* On Berlin Congress referred to before.

TABLE OF GEOLOGICAL ORDERS.

I	II	III	IV	V	VI		
SERIES.	GROUP.	SYSTEM.	DIVISION. ETAGE. COLORED.	BEDS OR ROCK ASSISE.	STRATUM. COUCHE. SCHICHT.	ERUPTIVE FORMATIONS. COLORED.	
(Time.)	(Era.)	(Period.)	(Epoch.)	(Age.)	(Phase.)	Acidic.	Basic.
Primitive.	Azoic or Eozoic.	Archeic.	Laurentian. Huronian. Taconian.			Granite, syenite, etc.	Serpentine, etc.
Primary.	Palæozoic.	Siluric. Devonic. Carbonic.	Cambrian. Ordovician. Silurian. Rhenan. Eifelian. Famenian. Bernician. Coal measures. Permian.	Each National Committee should be invited to fill in these columns with the names and particulars, palæontological, petrographical or topographical of the subdivisions or beds or of each single stratum as they occur (if they do occur in their respective countries), dividing if possible each division into three subdivisions.		Porphyres.	Melaphyres, etc.
Secondary.	Mesozoic.	Triassic. Jurassic. Cretacic.	Vosgian. Conchylian. Rhaetian. Liasian. Corallian. Bathonian. Wealdian. Cenomanian. Turonian.				
Tertiary.	Cenozoic.	Henocenic. Prehistoric.	Eocenian. Miocenian. Pleiocenian. Pleistocenian, Diluvian.			Trachytes, phonolites, etc.	Basalt dolerites, etc.
Quaternary.	Modern.	Historic.	Lössian.			Acidic lavas.	Basic lavas.

Europe, does not meet with general favor in the United States, and will not be accepted for general use in its present form, at least without strong opposition. It should be observed, however, that of those who have most devoted themselves to petrology in the above list, and whose authority on that branch of science is highest, one accepts the system unreservedly, and several others do not express any opinion.

M. Should Serpentines constitute one class of eruptives?*

PROF. DANA answers: "No."

SIR J. W. DAWSON: "Certainly not."

DR. HUNT: "No Serpentine is ever truly eruptive or plutonic."

PROF. LE CONTE: "If eruptive origin is undoubted, it should be made a distinct class, because its appearance, both in the field and in hand-specimens, is very distinct."†

PROF. IRVING: "No."

DR. EMMONS: "No."

PROF. G. H. WILLIAMS: "No."

PROF. HITCHCOCK: "Serpentine is an altered rock, one-fourth water." [Answer, presumably, "No."—REP.]

PROF. N. H. WINCHELL: "No."

PROF. WADSWORTH: "Serpentine, so far as I have studied it, when not a veinstone, is an altered condition of a peridotite, and comes as a variety under that eruptive rock. (See my Lithological Studies, pp. 189–192 for more fully expressed views.)"

PROF. EMERSON: "No."

CAPT. DUTTON: "I know of a great many serpentines which I think can be demonstrated to be altered peridotites. Regarding others, I await further research. I see no reason to dispute the

* [In Prof. Lossen's scheme the eruptives are arranged in seven groups, one of the separate divisions of each being selected to represent the group. The first group is "Granites, Syenites, etc."; the second, "Porphyries"; the third "Trachytes, Phonolites, etc."; the fourth, "Melaphyres, etc."; the fifth, "Serpentines, etc."; the sixth, "Basalts, Dolerites, etc."; the seventh, "Present Eruptions."—REP.]

† Prof. Le Conte's answer to the next question is that Serpentine is "always an alteration product." From this it would seem that his answer to this must be "No."

possibility that it may have been formed in other ways and from other rocks." [The plain meaning here is that Capt. Dutton is convinced that in many instances known to himself, serpentine is an alteration-product of one eruptive rock, and he thinks it likely that it may be an *alteration-product* of other rocks, but he nowhere implies that it may itself be an original eruptive. The inference, therefore, is that he votes "No."—REP.]

PROF. PUMPELLY: "No."

PROF. A. WINCHELL: "I think not."

Out of fourteen opinions, not one approves the selection of Serpentine as the type of a group of eruptive rocks. Thirteen reject it monosyllabically or by plain implication, viz.: DANA, DAWSON, HUNT, IRVING, EMMONS, G. H. WILLIAMS, HITCHCOCK, WINCHELL, WADSWORTH, EMERSON, DUTTON, PUMPELLY and A. WINCHELL.

Prof. Le Conte's answer is not definite, but is probably "No."

It may fairly be said that the bias of American opinion is against the acceptance of this as a class of eruptive rocks.

N. IS SERPENTINE (1) SOMETIMES OR (2) ALWAYS AN ALTERATION PRODUCT (3) OF ERUPTIVES, OR (4) OF SEDIMENTARY ROCKS, OR (5) OF EITHER?

PROF. DANA: "Serpentine occurs as a metamorphic eruptive, metamorphic sedimentary, or metamorphic metamorphic rock; not as an unaltered eruptive."

SIR J. W. DAWSON: "There *may* be eruptive serpentines, but I have not met with them. Serpentines, in my experience, are of three kinds: (a) *intrusive* rocks hydrated; (b) igneous veins (chrysolite, etc.); (c) beds and concretions in calcareous beds, *e.g.*, Laurentian limestones. They differ in composition as well as in origin."

DR. T. STERRY HUNT: "Serpentine is an indigenous rock of aqueous origin, and not a product of alteration."

PROF. LE CONTE: "I believe that Serpentine is *always* an alteration-product—sometimes of eruptives, but more commonly, in my experience, of sedimentaries."

DR. EMMONS: "Serpentine is always the product of alteration of some other rock or mineral, and probably quite as often of sedimentary as of eruptive rocks or minerals."

In another letter, he says: "Serpentine is always an alteration-product of eruptive or sedimentary material, as the case may be."

PROF. GEO. H. WILLIAMS: "Serpentine originates from the change of many eruptive rocks—generally Peridotites—and it is generally possible by microscopic study to ascertain the original rock. I know of no certain proof that Serpentine originates from sedimentary or chemically precipitated rocks, but I see no reason why it *may* not do so."

PROF. HITCHCOCK: "* * I am undecided, with a leaning to the view of Serpentine being an altered eruptive."

PROF. N. H. WINCHELL: "So far as I know, Serpentine is always an alteration product from other eruptives."

PROF. WADSWORTH: "Serpentine is, when not a veinstone, an altered condition of Peridotite." [See reply to M.—REP.]

PROF. EMERSON: "Serpentine is an alteration-product either of eruptive or sedimentary rocks."

CAPT. DUTTON: "Certainly sometimes an alteration-product of Peridotite, and possibly of other rocks." [See answer to M. —REP.]

PROF. PUMPELLY: "Always an alteration-product."

PROF. A. WINCHELL: "So far as my observation goes, Serpentine is always an alteration-product of sedimentary rocks."

Fourteen replies were received to this question. All but one regard Serpentine as an altered or after product, to wit: DANA, DAWSON, LE CONTE, IRVING, EMMONS, G. H. WILLIAMS, HITCHCOCK (doubtfully), N. H. WINCHELL, WADSWORTH, EMERSON, DUTTON, PUMPELLY and A. WINCHELL.

Alone DR. HUNT claims Serpentine as an original but not an eruptive rock.

The view of the majority also here may safely be taken as expressing the general opinion of American geologists.

CONCLUSIONS.

In summing up the conclusions drawn from the preceding work and attempting in them to summarize the drift of opinion of American geologists, it may be well to divide them into those which relate to questions concerning the general groundwork of the nomenclature and color scheme, and those appertaining peculiarly to the Archean.

As to the second class of recommendations, or those which relate exclusively to the Archean, the following points are submitted as fairly expressing the preference of the majority of those American geologists whose opinions were ascertained.

B. The division first in order of time shall have a rank of the first order and shall be called "Archean." (a.) It shall comprehend all the rocks of origin anterior to the Cambrian. (b.) The lowest subdivision of the Archean shall be called the Laurentian. (c.) A division between the Laurentian and the Cambrian provisionally including the Huronian, Grand Cañon, Llano, Montalban, and Taconian (of Hunt), Animikie, and other divisions shall be accorded a name different from any of them (such as Eozoic, Proterozoic, Eobiotic, Eomorphic, Agnotozoic, etc.), and allowing the greatest amount of liberty in the future, when it shall be determined whether the divison shall be entitled to rank as one (or several) of the first order, having numerous subdivisions as above mentioned; or with or including any of the second order like the class Laurentian. No attempt shall be made at this time to prejudge this question, and these names and this classification shall be regarded simply as the best that can be accomplished at the present time.

C. The two divisions of Archean (Pre-Cambrian) rocks just alluded to are probably separated by physical breaks from each other and from the Cambrian, but this has not been demonstrated sufficiently to enable it to be announced as an universal fact. Unconformability at these horizons, and indeed at various others, has been observed in various regions, but their true interpretation must await that greater knowledge of the Archean rocks which can only be attained by additional investigation.

D. Until such time as the Archean rocks can be correlated with each other in distant parts of the earth, it is best that geologists should distinguish them from each other petrologically without attempting to ascribe more than local chronological value to such distinctions.

E. The eruptives of the Archean, so far as they can be distinguished from the remaining strata, should be classified separately.

While there is a difference of opinion on the subject, a large majority seems to favor the classification of all eruptives together, whether of Archean or Cenozoic age (following the view of Von Dechen); the reason being that as great differences between

them result from varying conditions of heat, pressure and time of cooling, as from alterations and metamorphism produced in the oldest of them after they were congealed.

F. The opinion of American geologists is almost unanimous against the introduction into the nomenclature, at this time, of the terms Hebridian, Dimetian, or Arvonian; though this is not meant to imply that if in the future convincing proofs are presented of the existence of these series over a sufficiently large part of the earth, they may not then be adopted, subject to the ordinary rules of priority which determine questions of nomenclature.

G. There is a wide difference of opinion as to whether there are crystalline rocks in and later than the Paleozoic, which are indistinguishable from those of the Archean. It follows, therefore, that there is the same difference of opinion as to whether lithological evidence is of any *general* value in determining even broadly the chronological position of a rock.

H. Specifically with regard to the Laurentian, however, there seems to predominate the view that some of its rocks have never been repeated, and are thus determinable as Laurentian lithologically where present in large enough masses.

I. Mineral constitution is not indicative of geological age, but it is the belief of the majority that with profounder knowledge it may one day become so.

J. The lower crystalline rocks are: some of aqueous origin metamorphosed; some of igneous origin metamorphosed. It is not always possible with our present knowledge to distinguish the one class from the other.

K. There are evidences of life in the rocks anterior to the Cambrian, but not in the Laurentian.

L. Eozoon Canadense is probably not of organic origin.

LL. The scheme for classifying eruptive rocks which was formulated by Prof. Lossen and adopted by the International Committee for employment on the geological map of Europe, is not generally approved by American geologists, who regard it as a temporary expedient for the specific purpose mentioned, which should be modified as further experience shall suggest before it can be adopted as an universal classification.

M. Among other reasons for modifying this scheme is its

selection of Serpentine as the type of the fifth division of the eruptive rocks, which is inadmissible because—

N. Serpentine is all but universally regarded as a product of alteration either of Peridotite (the commonest view) or of that and other eruptives, or even of sedimentary rocks.

O. It is better that the word Taconic as a term of Archean classification, be dropped altogether. But if employed it has been proposed by Dr. Hunt for the place of the uppermost division of the Archean, where this division can be made out.

It is recommended that the American Committee use every proper means before the next Congress:

1st. To have the word 'Group' of the Committee on Nomenclature substituted by Realm for the most comprehensive stratigraphical division.

2d. To have it officially declared that neither the color-scheme for the proposed map of Europe, nor the classification of eruptives of Prof. Lossen, provisionally adopted by the map-committee in order to bring out the map, are other than tentative schemes, subject to alteration when their application to the map shall have shown to what extent they are deficient.

3d. To cause it to be understood that American geologists will acquiesce in the recommendations of the Congress by sacrificing individual opinions to a reasonable degree, provided that these recommendations do not hamper the efforts of research by requiring more correlation of beds between the two continents than observation can justify.

NOTE I.

In this connection it would be impossible to pass over a work which displays on this subject great erudition,* written chiefly, as its title indicates, to establish the claim of one of its authors to priority in the name of Azoic as applied to the Pre-Cambrian rocks, and to vindicate the appropriateness of this designation. The following very condensed summary of the argument in the Resumé it is hoped does this work no injustice. The term Azoic was used by Murchison in 1845, for the crystalline masses in Scandinavia which he found underlying those beds which he deemed to be the exact equivalents of the Lower Silurian of

* The Azoic System and its proposed Subdivisions.

England. Though these crystalline masses were found under conditions of heat and fusion when it was hopeless to expect traces of organization, yet he would not dogmatically affirm that they might not contain fossils. In 1851 Foster and Whitney adopted the term, limiting it to those of detrital origin. At this time Logan, under the influence of Lyell's teaching, called the lower series of the Canada Survey metamorphic, but after 1854 changed the term to Laurentian, which he applied to the Azoic of Foster and Whitney. Dana, first in 1862 and then in 1871, adopted Foster and Whitney's Azoic, but included under it not only detrital rocks but those which constituted the first floor of the globe. Afterwards, in 1874, in a second edition, he adopted Archean time with an undefined Azoic age as its first term, and finally that age in which the earliest forms of plants and animals appeared. Foster and Whitney gave the name Azoic in 1850 to a body of rocks which were in part sedimentary, and in which no fossils were found and which everywhere underlay those strata in which the earliest fossils occurred. Profs. Whitney and Wadsworth claim that up to the present time, after thirty years' work on them, no proofs of fossils have been furnished. Eozoon is considered of inorganic origin on the evidence of Möbius, Zittel, Carter, Rowney and King, and finally, and, as they hold, conclusively proved to be so by their investigations of the eozoonal structure at Stoneham, Mass., which they found to be in a segregated or vein-like deposit of earlier date than some of the disks, but posterior as to the formation of others. They concluded that the calcareous mass was the result of the action of thermal waters, etc. At Chelmsford the eozoonal limestone was entirely crystalline, and filled with scapolite, actinolite and other silicates. Similar conditions applied to the limestone at Devil's Den and Devil's Basin. The notion that those coral-like bodies and rhizopod masses resembling Stromatopora found by Dr. Geo. W. Hawes in the massive chloritic rocks of New Hampshire were organic, which Sir J. W. Dawson pronounced like parts of Bryozoans, Entomostracans, and some Devonian plants, was abandoned by Dr. Hawes himself two years later.

The evidence of limestone as to the existence of organic life is rejected because carbon as graphite can exist in iron, and is found in the iron and the basaltic rock of Greenland. In oppo-

sition to Bischof's statement that graphite is not found in the unstratified crystalline rocks, it is maintained that it is "almost exclusively confined to granite, gneiss, quartz, mica-slate, crystalline limestone, and the older slates." The claim, therefore, that graphite is a proof of organic life is unfounded; no traces of new life having been found in the graphite of the Azoic series. Carbonate of lime does not imply the intervention of organized beings, as its formation is constantly going on without them. Iron ores also do not prove the presence of organic life, as iron is one of the commonest components of eruptive rocks. To sulphur the same argument applies, and to apatite as proving by phosphorus animal life. Finally he demonstrates that the rocks called by Foster and Whitney "Azoic" are in fact non-fossiliferous. 2d. As to the grounds for dividing the Pre-Cambrian into two or more classes, the division of the Laurentian from the Huronian by the appearance of fossils in the latter, was abandoned by the Canadian Survey. The Aspidella as a fossil is dismissed as a concretion intersected by small irregular cracks. The Arenicolites spiralis is, on Dr. Wadsworth's examination, rejected.

The division of the Laurentian from the Huronian is attributed to Logan's confounding the basaltic volcanic rocks interbedded with the Potsdam sandstone of Keweenaw Point with the basic or greenstone portion of the Azoic of Foster and Whitney as developed north of Lake Huron. In regard to the accepted succession and unconformability, the Huronian resting on the upturned edges of the Laurentian, it is stated that of the seven cases in the Canada Survey, when the contact was observed, in five they passed imperceptibly into each other; in a sixth they show mutually intrusive relations, and in the seventh the Huronian abuts against and runs under the Laurentian.

The conclusion of this laboriously prepared work is that there is undoubtedly a series of rocks beneath the lowest fossiliferous horizon; that this series has thus far proved unfossiliferous; that it has been called Azoic by Foster and Whitney before Logan applied the terms Laurentian and Huronian to his former "metamorphic"; that no division has been found which holds good over an extended region; and that hence the rocks in question should be called the "Azoic," and should not at present be divided. It appears to your reporter that the main question

to be here considered is that of priority, and, inasmuch as it is conceded that the term "Azoic" had been employed by Murchison in 1845 for rock masses which he conceived to be sub-Silurian in Scandinavia, and of which the parallelism with the rocks of Foster and Whitney had not been established; and that, therefore, this application of the term was at least as unauthorized as was that of "Laurentian" by Logan (which had "been previously proposed by an eminent authority for a group at the other end of the geological series"); that the term Azoic has no right to monopolize a sequence of measures, which, to say the least, it is not certain that the word describes. Even if it be granted that the supposed recognition of fossil forms in these measures is erroneous, the assumption of the important characteristic of absence of life for rocks, which, according to Whitney and Wadsworth,—"did *not* show by their character that life could not have existed at the time of their deposition"—would be to do violence to all those principles of inductive research which Profs. Whitney and Wadsworth insist should be considered of paramount importance in geological study. On the other hand, the acceptation of a name of general significance, like Archean, for all the Pre-Cambrian rocks, while not begging the question of the existence of life, leaves it free for the local worker or the Government survey to adopt subdivisions as broad as investigation can justify. If workers at once agree that no final classification can be attempted while the whole subject is in the chaotic state of a preliminary examination, there should be no objection to a temporary grouping of objects together, even although one characteristic of one of the groups should hereafter be found to resemble one of the characteristics of another above it.

Note II.

In the report prepared before the Berlin Congress by the English sub-committee on Archean (Pre-Cambrian) rocks, Mr. Aveline doubted the existence of any Pre-Cambrian rocks in England or Wales, and thought that the Laurentian rocks of Scotland, which he had never seen, were, probably, the only Pre-Cambrian rocks in Great Britain.

Dr. Callaway classified these rocks upwards into (a.) Hebridian, probably including the Malvern gneiss; (b.) Dimetian, probably

distinct and younger than the Hebridian. The gneissic rocks of Anglesey and some of the newer gneiss of the Highlands may belong here. (c.) Pebidian, a well-marked group recognizable at St. David's, in the Malvern Hills, and in the counties of Shropshire, Caernarvonshire, Anglesey, Dublin and Wexford. [The Arvonian of Hicks is, in some places, a part of the Pebidian, and in others of an older gneissic group.]

Dr. Hicks describes his classification of the Pre-Cambrian (Archean, or Eozoic) rocks as Dimetian, the oldest known in Wales, having a granitoid character, and consisting of quartz, feldspar, and a chloritic mineral; or a schistose character, where (as in Anglesey) mica is also found in them. In other places they consist almost entirely of quartz. The Arvonian consist of compact highly quartzose rocks of the hälleflinta type, of felsi-quartzites, and of rhyolites and acid breccias. In some places they are unconformable and in others apparently conformable, as the Dimetian. The Pebidian consists mainly of rocks of volcanic origin, alternating with schistose, micaceous, chloritic and talcose rocks. Instead of acid rocks being, as in the Dimetian and Arvonian groups, the prevailing types, the basic rocks predominate. Agglomerates and breccias occur in great thicknesses. Serpentinous and dolomitic rocks are also found at various horizons. It is a group of great thickness and appears to be unconformable to the Arvonian. It is covered everywhere in Wales by the newer rocks, and the lowest Cambrian conglomerates are almost entirely made up of the waste of this and of the preceding groups.

In Scotland the Archean rocks may be conveniently divided into at least four groups. The lowest in stratigraphical position, as far as I have examined them, is the Loch Maree group, and it consists of the massive hornblendic and the granitic gneisses found in many places along the west coast of Sutherland and Ross. Next in position I would place the massive quartzose and granitoid gneisses of Poolewe and of Loch Shiel of the more central Highlands (the Loch Shiel group). In many respects these may be compared with the Dimetian of Wales. The next group, according to my views, would include the Glas Bheinn (rather massive epidotic and chloritic gneisses, hornblendic rocks and black mica schists), and the Ben Fyn series. The latter consist of coarse and fine-grained quartzose gneisses, silvery mica schists,

augen gneisses, and micaceous gneisses, with bands of white and black mica. (This may be called the Ben Fyn group.) Newer than these probably are some rocks in the Grampians and along the shores of the Caledonian Canal, which I have called the Grampian series. They consist mainly of fissile mica-schists, flaggy micaceous and chloritic rocks. In the series also are some talcose, actinolitic and serpentinous rocks. Bands of limestone are also found in them. They probably occur also in Sutherland, according to descriptions of Dr. Callaway and Prof. Lapworth, and from the evidence of included fragments in the Cambrian conglomerates of these areas. * * *

Mr. Hudleston, in a discussion reported in the Geological Society's Journal (Q. J. G. S., vol. xxxiv., p. 167), remarks: "When instituting a comparison between the St. David's district and North Wales, the principal datum-line seems to be the great conglomerate taken as the base of the Cambrian, which may be deemed fairly synchronous in both areas. The point at issue was whether the beds *below* this, . . . were really Pre-Cambrian, or had been metamorphosed and intruded at a subsequent period. The contents of the conglomerate were very much in favor of the author's views." The author (Dr. Hicks) maintains the Pre-Cambrian age of the beds.

In another discussion (Q. J. G. S., vol. xxxv., p. 326), Mr. Tawney, referring to the so-called "Arvonian Rocks," doubted the advisability of coining a new formation to include the quartzites near Haverford West, and the quartz-felsites and grits near Bangor, until their relations had been worked out more in detail; the proofs of unconformity to rocks above and below he also regarded as dubious.

The following views are expressed by Professor Bonney, with regard to certain rocks in the Highlands (Q. J. G. S., vol. xxxix., p. 161): "In examining these Highland rocks (and I may say others also), I have observed three rather well-marked types, indicating stages of metamorphism. In the first it is obvious that many of the constituents noticed in the slide, especially those of larger size, with most of if not all the feldspar, are original. . . . . Of this stage of metamorphism the rocks forming the escarpment of the 'newer gneiss,' in the neighborhood of the head of Loch Maree, furnish excellent examples.

"In the second stage of metamorphism, while, when we regard

the rock in the field, we can have no doubt of its sedimentary origin, bedding being often well-marked and foliation distinct, yet, under the microscope, it is extremely difficult to identify any of the constituents, in their present condition, as of clastic origin . . . of this stage of metamorphism, which, so far as we can tell, is as complete as can be. The rocks of the southern face of Ben Fyn furnish excellent examples. In England I may cite as instances the schists of the Lizard peninsula, and a considerable number of those in Anglesey, though some which have been sent to me from that island belong rather to the former type.

"Between these types, intermediate instances will, of course, be found. The third type, while agreeing with those described under the second head as being metamorphosed to the highest degree, appears to differ in respects which can hardly be due to a mere prolongation of the metamorphic action. The bedding of these rocks is ill-marked; they are coarsely crystalline and often granitoid in aspect, being then difficult to distinguish from rocks of igneous origin, and the same is true of their microscopic structures. In such cases, in the present state of our knowledge (though I do not think it will be so always), we must be content to be sometimes uncertain whether we have before us a granite or a gneiss. Examples of this class are the coarse gneisses of the Hebridian series, which underlie the Torridon sandstone and many of the Malvernian rocks of England. At the same time it must be remembered that now and then beds more distinctly foliated also occur in this series.

"Naturally we should expect that, as a rule, the above distinctions should have a certain chronological value, and thus we are justified in using them in default of other evidence and with due caution for purposes of classification."

In a paper (Q. J. G. S., vol. xxxix., p. 261) "On the supposed Pre-Cambrian rocks of St. David's," by Dr. A. Geikie, the author denies the existence of any such rocks in the St. David's area. In the discussion which followed this paper, Prof. Bonney remarked, "As regards the separation of the Pebidian from the Cambrian, to himself there appeared to be an unconformity at the base of the quartz-conglomerate, certainly there was an entire change in the lithological character of the deposits. The conglomerate introduced a series of beds different in aspect, color, materials, and conditions. He did not say, and never had thought, that

the break between the Cambrian and Pebidian was necessarily a very great one."

Professor Lapworth "asked if the name Cambrian was to be carried down indefinitely. He had found rocks resembling these Pebidian volcanic beds underlying fossiliferous Cambrian strata in central England and round the Longmynd."

Mr. Hudleston "had difficulty in recognizing the supposed unconformity between the Cambrian and the Pebidian, and he thought that the volcanic series was the natural base of the Cambrian system." At first sight there is an apparent contradiction between these remarks and those previously quoted at p. 133. This arises from the briefness of the reports. Mr. Hudleston's view is that "there can be no question that the volcanic series antedates the conglomerate; but it is highly probable that far too much importance has been assigned to the physical break, which, in areas admittedly volcanic, is only of minor importance for purposes of systematic arrangement. Prof. Bonney (Q. J. G. S., vol. xxxix., p. 464) refers to the separation of the volcanic beds of Bangor (identified as Pebidian) from the rocks underlying them, and also from the Cambrian; "from the latter" he says, "we seem justified lithologically and physically in separating these more or less volcanic beds, and in including them for convenience in the Pebidian groups of Dr. Hicks; but the interval in time need not have been a very enormous one. Below the rhyolites, as it seems to me, is the great gap in the record."

From a consideration of the foregoing statements, your reporter would offer the following suggestions concerning the classification of the Archean rocks of Britain.

(i.) Below the Cambrian beds as originally defined by Professor Sedgwick, there are a series of beds, chiefly volcanic, which have not undergone any very great metamorphic change. These may be spoken of as the Pebidian type, being first described by Dr. Hicks under that name. As they are by many writers stated to be well separated from the overlying Cambrian beds, and as they were not included in that system by its founder, they cannot justly be included in it, but must be grouped with the Pre-Cambrian rocks.

(ii.) At the base of these beds occurs the most important break, as shown by physical discordance, and change from comparatively unaltered to highly metamorphosed rocks.

(iii.) The rocks below this break have not as yet been satisfactorily classified, but these three stages of progressive metamorphism, which, as Professor Bonney remarks, in a paper above alluded to, have a certain chronological value.

(iv.) No break has yet been satisfactorily proved to exist in Britain between two divisions of these highly metamorphic rocks.

[NOTE.—To this report was added another appendix, embodying the verbatim replies of some whose opinions were quoted by the reporter. As these are all condensed and embraced in the body of the report, they are omitted here.—EDS. GEOLOGIST.]

Report of the Sub-Committee on the Lower Paleozoic.

N. H. WINCHELL,
REPORTER.

In response to the appointment as reporter on the Lower Paleozoic at the meeting of the American Committee of the International Congress of Geologists, held at Albany, in April last, I beg leave to offer the following report.

A short conference between Professors Williams and Stevenson and myself resulted in an understanding between ourselves as to how much of the paleozoic column should be included in the term Lower Paleozoic. It was agreed that the rock-masses containing fossils, lying below the generally recognized base of the Devonian in this country (the *Cauda-Galli grit*), should be considered as belonging to the *Lower Paleozoic*—in other words, the *Silurian* and *Cambrian* strata as now generally recognized.

Your reporter finds it difficult to divest himself of his personal predilections, and to approach the task of presenting a digest of the aggregate opinion of American geologists that may differ from him in their opinions, and in their estimates of the importance of scientific data and of historical facts; and he begs your forbearance at the outset, and can only assure the Committee that he has striven to deal impartially with all the evidence and opinions that have come to his notice.

Besides the general notice published by the Secretary of the American Committee (Dr. Frazer), but little further effort was made to elicit expressions of personal opinion from individual geologists. Some opinions, however, sent to Dr. Frazer, in response

to a set of questions proposed by him relating to the Archean, have been referred to the sub-committee on the Lower Paleozoic, as they fall within the scope of the Lower Paleozoic rather than that on the Archean, and the import of these is embraced in the following report. Whenever any working geologist has published his views on the nomenclature of the Lower Paleozoic, his published opinions have been considered to be his final and present convictions, and have been accepted as such. It became evident, however, that a comparatively small number of American geologists would have to pronounce on the questions involved, and to render the decision which this committee should adopt for report to the London Congress. To some of these I addressed personal letters of inquiry, and I have received important communications from Professors James Hall, Albany; C. H. Hitchcock, Hanover; J. D. Dana, New Haven; Alexander Winchell, of Ann Arbor; Messrs. C. D. Walcott, Washington; S. W. Ford, Schodack, and Dr. J. S. Newberry of New York. Mr. Walcott, however, in the week just preceding the meeting of this committee at New Haven, Conn., withdrew his communication, and has not supplied me with any other. I have been obliged, therefore, to rely on his published statements of fact and opinion, so far as they bear upon questions involved in the following digest.

Your reporter would call attention to the fact that, owing to the great divergence of opinion among American geologists on some of the questions involved in the nomenclature of the Lower Paleozoic, it is an exceedingly difficult task to compare and digest them so as to make a consistent stratigraphic scheme; and that it is impossible to reduce them to any symmetry without doing violence to the convictions of some. It is, on the other hand, a pleasure to state that, owing to the researches of Messrs. Dana, Marcou, Ford, Walcott, Wing, Dwight, Dale, and others, some of these unsettled differences appear recently in new garbs, and may be approached anew with some confidence, in the expectation of arriving at a nearly or quite unanimous conclusion. Your reporter has studied carefully all published literature, and has had correspondence with numerous geologists, and he offers the appended classification of the Lower Silurian and Cambrian rocks of America as the result of this study. He does not flatter himself that all geologists who have studied these rocks will be willing to accept this classification. Such were a vain hope; but he be-

lieves that it expresses the nearest approximation to the truth that can now be formulated.

In attempting to canvass opinions and to weigh scientific evidence, when there is so much diversity, the necessity falls upon the reporter to rely on his own sense of justice and his appreciation of the value of scientific fact and testimony, and with these criteria for guidance, to reach what seems to him to be a fair adjustment of the various opinions. This your reporter has tried to do; and while the result may not be that which all will approve, yet he is solaced in the midst of such criticism as may be made by the reflection that it matters not what other result had been arrived at he would still not have escaped, perhaps, an equal amount of criticism, and by the reflection that the recommendations herein embodied are the result of his honest convictions of the truth after long and painstaking study.

Professor H. S. Williams, at the Albany meeting of the Committee, suggested an important fundamental idea, and one which may influence materially the final distribution of terms in stratigraphic nomenclature, viz., the adoption of a dual set of designations—one set, that referring to the lithological character of the rock-masses and based on geographic names, will be liable to vary as the strata change from place to place, and the other, based on some great and persistent life-characters, shall refer to the faunas of those rock-masses and be substantially constant over large areas, and perhaps over the world. It is very evident that great confusion has resulted in the past, among geologists, by confounding these distinctions, and much controversy has arisen in attempting to maintain one or the other of these different zonal designations. Stratigraphic work has been ignored, or at least neglected, by paleontologists, and the practical field geologist has been tempted, in some instances, to ignore, if not to deny, the assertions of the paleontologist. Instead of this confusion there should be introduced some new departure. The confusion results from a confusion of nomenclature. Faunal characters have been made to have the force and the usage of stratigraphic designations and have been extended as stratigraphic features, over strata where the faunal characters are wanting. Again, stratigraphy, based on natural and great lithological distinctions, having been defined in one region by its faunal associations, is extended over other states by one geologist so far as he

finds the lithology to warrant, and by another so far as he finds the paleontology to warrant.

There are, hence, two laws by which we must be governed in framing a scheme of nomenclature which shall allow the freest rein both to the stratigraphic geologist and to the paleontologist. One relates to the work of the stratigrapher, who takes account of the great physical changes to which the earth's surface has been subjected, and the other refers to the work of the paleontologist who strives to delineate the organic changes which the surface of the earth has witnessed. These changes have been supposed to be coeval and coextensive; but our investigations show they have not been so entirely. But we sometimes have the same fauna, or nearly the same, living under different circumstances and, perhaps, also at different dates in different parts of the world.

So long as the geology of the United States, for instance, was known accurately in only one part (New York State) the faunal characters which the formations were found to exhibit were seen to be coincident with the stratigraphic to so great an extent that there was no reason to dissociate them under separate schemes; but since the whole area of the United States is being brought under careful examination, it is found that the close connection which these two classes of characters have in New York State is broken up and they begin to diverge gradually in various places and in different ways. The same experience is found, to a greater or less extent, as any local terms are extended from any of the states into those contiguous. This plainly shows that unless there be allowed great freedom to vary from the scheme adopted for stratigraphic designations, any nomenclature which the Committee or the International Congress may adopt, will be but a short-lived experiment.

It will obviate all this confusion if the suggestion of Prof. H. S. Williams be adopted, and one set of names be chosen for the lithological characters and another for the faunal.

The stratigraphic terms should be wholly geographic and should be allowed to change as often as local geologists deem it is necessary. The faunal terms should be very broad in their scope at the outset, and subdivisions should be introduced as fast as the special sub-faunas are discovered and defined.

In making recommendations of the following table of nomen-

clature your reporter has been guided by the foregoing considerations.

Mr. C. D. Walcott, whose recent work in the stratigraphy and paleontology of the Taconic makes his opinion of great significance and value, and whom several geologists are disposed to follow entirely in their own opinion and recommendations, advises the qualified adoption of the term Taconic in the nomenclature of the Lower Paleozoic rocks.* It became necessary not only to adopt his discoveries and recommendations, coincident as they are with Mr. Ford's which preceded, but, owing to the recognition of the first mentioned principle already formally adopted by this committee (a dual nomenclature), to give them a somewhat wider application. In making this wider application, and in the multiplying of terms by the differentiation of paleontologic from physical characters in accordance with the recommendation of the director of the United States Geological Survey, Major J. W. Powell, one of the great difficulties of geologists in choosing terms for the Lower Paleozoic is obviated. The various conflicting terms are allowed to overlap each other without confusion by placing their conflicting elements in different columns. It so happens that the chief conflict, that between the terms *Cambrian* and *Taconic*, can be wholly obviated by this differentiation. The Cambrian paleontologically embraced only the second fauna, but physically it covered also the rocks of the first fauna. The Taconic pertained only to the first fauna paleontologically, but physically it embraced also the rocks of the second fauna. When separated thus they do not conflict, for the faunal idea is separated from the physical, and in its own ground, where it should be recognized, each has supremacy.

Your reporter regrets exceedingly that, since the withdrawal by Mr. Walcott of his former communication, read to the Committee at the Spring Lake meeting, he has not received from him any other statement, and has to rely on the late published account of his latest discoveries, in the *American Journal of Science*. The facts there put forth, however, only confirm Mr. Walcott's former statements, and are consistent with the recommendations of this report.

Other communications which have been sent to your reporter

* See Note on p. 215 for Mr. Walcott's revised opinion.

are given below, or are summarized so that their substance and evidence are expressed.

PROF. J. D. DANA'S VIEWS.

NEW HAVEN, March 17th, 1888.

PROF. N. H. WINCHELL:
MY DEAR SIR:

* * * * * * *

My conclusions with regard to the Taconic formation, now fully sustained by the new discoveries of Walcott, are, as set forth in my papers, that it includes the whole of the Murchisonian "Lower Silurian," that the chief part of it is above the now-called Cambrian; but that the quartzite, the least characteristic part in the 1842 Taconic, is a promiment member of it. It lies directly beneath the limestone, and probably covers not only the Middle Cambrian, but also the true Potsdam, if not simply the equivalent of the Potsdam.

As to the use of the name Taconic for the Cambrian, or for any part of it, or any part of the Lower Paleozoic, there is, in favor of the term, that it is short, is familiar, and has been employed for all parts of the "Lower Silurian." But I believe it will be regarded after awhile as a reminder of Emmons's blundering work—a succession of unstudied assumptions that brought only evil to the science. For his reputation I would say that the sooner the name disappears from scientific nomenclature the better.

I think that there would be nothing gained by substituting Taconic for Cambrian; and also that the attempt to make such a substitution would be fruitless. The use of the term for either subdivision of the Cambrian would not be well because no subdivision of it stands out in the Taconic so prominently as to suggest it. It could be used with least objection, for the Lower Silurian, above the Cambrian, in place of the disagreeable term Ordovician or Ordovian.

It could properly be used also for the whole of the Murchisonian "Lower Silurian," that is, be made to include the Cambrian and the Lower Silurian as some now write it. In this case the Paleozoic below the Devonian would embrace the Silurian = Upper Silurian; and the Taconic = Lower Silurian, the latter

covering the periods, (3) Trenton; (2) Chazy (embracing Chazy and Calciferous) and (1) the Cambrian.

To this use of the term, or the preceding, I would give my assent.

* * * * * * *

Very truly yours,
JAMES D. DANA.

RECOMMENDATION OF MR. S. W. FORD.

The opinion of Mr. S. W. Ford is expressed in the following brief communication:

SCHODACK LANDING, N. Y., August 2d, 1887.

PROF. N. H. WINCHELL:

MY DEAR SIR: Your favor of June 26th, requesting an expression of my views concerning the nomenclature of the American Lower Paleozoic, is at hand.

I fear that I have given less attention to this subject of late years than its importance has deserved; but my classification and chronological arrangement of the American formations, from the Acadian or *Paradoxides* beds to the top of the Lorraine or Hudson River group, would at present be as follows:

1. The rocks, from the base of the Calciferous sand rock to the top of the Lorraine, I should call "Lower Silurian," retaining the names by which they are at present known for the several subdivisions thereof. The "Quebec Group" of the Canadian geologists appears to me to be about the equivalent of the Calciferous and Chazy of the New York geologists.

2. The three great fossiliferous formations below the Calciferous, viz., the Potsdam, Lower Potsdam (or Georgian), and Acadian, I should call collectively Cambrian, and regard them as constituting a system as distinct from the Silurian as is the latter from the Devonian. For its middle portion, or that marked by the genus *Olenellus*, I would advocate the adoption of the term "Taconic," as a deserved tribute to the labors of Dr. Ebenezer Emmons.

Geologists may differ as to the propriety of drawing the line between the American Silurian and Cambrian at the base of the Calciferous, but I am convinced that there is a faunal change at that horizon of sufficient importance to demand it.

I should further feel disposed to urge the retention, if possible, of the term "primordial fauna," as a legitimate designation for the fauna of the Cambrian rocks, in recognition of the eminent services of Mr. Barrande in that direction. Of course, if we adopt the term Cambrian for the rocks holding the "primordial fauna," the latter term becomes unnecessary; but I should much regret seeing it altogether discarded.

It may well be, however, that between the Acadian group of the American Cambrian and the Archean, there are beds holding a still more ancient fauna, of which there is at present perhaps some slight evidence; and if so, and if further, the fauna of these beds should prove sufficiently distinct from that of the Cambrian to warrant the placing of the two in different systems, the term "primordial fauna" as applied to the fauna of the Cambrian, would then, of course, cease to be even paleontologically appropriate. At present, however, the beds in question have been too imperfectly explored, it seems to me, to enable us to assert with any degree of confidence, that they do not constitute a legitimate portion of the Cambrian system.

Very sincerely yours,
S. W. FORD.

PROF. JAMES HALL'S COMMUNICATION.

Prof. James Hall's communication states:

"As to your first question as to adopting exclusively European terms, I should say, no! It matters perhaps little what the more comprehensive names, as Silurian, Devonian, etc., may be, but the lesser terms must be those well-known and well-sustained—and among the fossiliferous rocks, by their determined fossils. I do not believe that we shall give up any of the American well-sustained determinations. I have not the strength to go into this discussion just now. * * *

"In regard to your last inquiry, about the Taconic—were it left to me I should say that we drop all the earlier phases of the question, when Emmons was basing his system on the crystalline limestone and altered shales, and sifting it clear of those earlier mistakes, apply the name to the rocks below the Potsdam, according to his conception, but not according to his earlier demonstration."

FROM PROF. C. H. HITCHCOCK.

Prof. C. H. Hitchcock writes as follows:

HANOVER, N. H., July 8th, 1887.

PROF. WINCHELL:

DEAR SIR: * * * * Specifically (1) as to Taconic, I am satisfied from the late paleontological discoveries of Walcott (which agree with Emmons' paleontological work) that the lowest Taconic rock is of Lower Potsdam age. Hence it is not proper to assign any of it to the Archean. I suppose that Hunt includes with his known Taconic, rocks of similar mineral character which as yet have not afforded fossils, and it is these unfossiliferous rocks that he refers to the Archean. I should say, let all the indefinite rocks, *quasi*-Archean or *quasi*-Potsdam, remain indefinite, in which case the local geologists will place them, some in one and some in another group. The Committee have not the ability to put uncertain rocks anywhere.

Emmons called the Burlington, Vt., sandstones Potsdam (American Geology, Pt. ii., p. 128). In my Vermont papers I have shown this rock to be the stratigraphic equivalent of the Granular Quartz, and the paleontologists have since discovered Olenellus in both the sandstone and the quartz. Hence we need not hesitate to include the Potsdam with the Taconic, whether it be regarded as a system or a series.

(2) As to the name Taconic itself you have my two suggestions, either to say Taconic *pro honoris causa*, or use Potsdamic in the sense of the rocks holding the first fauna of Barrande; I would not use the term Taconic at all as an inferior designation. *Aut Cæsar, aut nullus.*

(3) I do not think it will be wise to drop the smaller American names, like Niagara. We may use the names of the *Systems* for the whole world, but not any terms of inferior grade. We can say Silurian the world over, but not Wenlock nor Niagara nor any similar name.

We must have a twofold nomenclature as you suggest and as I understand Prof. Williams. Thus we can have the time when *Trinucleus* lived for one division, the time of *Paradoxides* for another, and so on. It will be well if the paleontologist will find illustrations of longevity to characterize every time division. The trilobites furnish an illustration. They are confined to the Paleozoic, so the Paleozoic is the Era of trilobites. Each system

has probably its representatives, and you can find species that will be limited to the phases and stages. The longer the vertical range of the division, the more comprehensive the assemblage of trilobites will be that will fit it.

I should say that the name should be derived from the usual geographical locality, and the applications of paleontological terms be subordinate, partly because the classification will be comparatively new—partly because the paleontologists must be able to extend the range of species by new discoveries. Even the Ammonite is proved to be Cenozoic, yet there is scarcely any form of life that is more characteristic of the Mesozoic.

I think that Barrande has made the most thorough classification of the Lower Paleozoic rocks, and should be inclined to follow him. He it is that set the English geologists right and also the Americans twenty-five years since.

DR. T. STERRY HUNT.

Dr. T. Sterry Hunt in recent papers in the American Naturalist has reviewed the Taconic question. He discards entirely the investigations which during the past fifteen years have been carried on in the eastern portion of the Taconic area by Dana, Dwight, Wing and others, and reaches the conclusion that the Taconic consists of two parts, one primordial and one pre-primordial. This is diverse from the late result of Mr. Walcott, who states unqualifiedly that the lowest rock of the Taconic of Emmons contains primordial fossils. The primordial section of the Taconic, Dr. Hunt would group in the Cambrian, and the rest of the Taconic he would maintain as a distinct portion of the Archean.

PROF. JULES MARCOU.

Mr. Jules Marcou, of Cambridge, in the Proceedings of the American Academy of Science and Arts, of Boston, about three years ago published a strong and lucid argument, based on stratigraphic and paleontologic facts and on historical documents, showing the right and the prior use of the term Tacónic in geological nomenclature.

DR. ALEXANDER WINCHELL.

Dr. A. Winchell, of Ann Arbor, has given me a thorough and independent review of the whole Taconic controversy, based on

an examination of the early original documents. This paper is too voluminous to incorporate into this report, and I can only give a brief summary of it. He reviews the original proposal and fundamental idea of the founder of the system, in point of definition, stratigraphic position, geographic distribution, constitution, reasons for existence, lithologic distinctness, stratigraphic unconformities and paleontologic characters. This idea he finds to be borne out in the existence of a real sub-Silurian system both in Europe and America, the fundamental ideas of Murchison and of Sedgwick not at all colliding with that of Emmons, the only real conflict being between Messrs. Murchison and Sedgwick in England, as to who should occupy and name what he styles the "Silurian Annex"—the Bala group of rocks. He next compares the Taconic with the Huronian and with the primordial zone of Barrande. These two ideas collide with the Taconic, one structurally and the other faunally, but they are both of later date and have to give way on that ground. He then states the position and equivalences of the Taconic system, quoting the recent results of Messrs. Walcott and Ford, and the opinions of Mr. Marcou, of Cambridge, and M. Dewalque, the General Secretary of the Committee on Nomenclature of the last Congress, and concludes with the following brief tabulation, which he favors:

III. Silurian [= Upper Silurian, containing the 3d fauna].
II. Cambrian [= Ordovician, containing the 2d fauna].
I. Taconic [Containing the primordial fauna].

FROM DR. J. S. NEWBERRY.

The following communication from Dr. J. S. Newberry, of New York, embodies his recommendations on Paleozoic nomenclature.

COLUMBIA COLLEGE, NEW YORK, February 17th, 1888.

PROF. N. H. WINCHELL:

MY DEAR SIR: I have to-day received your letter with the accompanying (preliminary) report, which I have read with much interest, and return to you. I agree with you fully that it is very desirable that Emmons' discovery of fossiliferous strata below the Potsdam should be, if possible, recognized in our geological nomenclature. It is true that he made many mistakes, and his Taconic system, as he defined it, cannot be accepted. He

included in it in Vermont and Massachusetts strata which have been shown to be Lower Silurian, and in North Carolina those which are below the typical Taconic; but he was certainly the first to recognize what have since been called the Georgia, or Olenellus slates, claiming that these were beneath the Potsdam sandstone, while all the world was against him. If it were possible to attach his name to that group, my sense of justice would be gratified. My method of accomplishing this would, however, be a little different from yours, as I would make the Taconic the upper member of the Cambrian, the St. John's group and perhaps the lower portions of the great Cambrian series at the west other and older subdivisions.

The classification of our Paleozoic rocks by faunas alone seems to me one-sided, and I think the physical history of the strata should also be considered. We all know or believe that the streams of time and life have flowed on continuously in the world's history, and if we could obtain access to the sediments which have accumulated in the sea basins that have always been such, we should find the record without breaks; the successive faunas interlocking in such a way that no sharp lines could be drawn between them. It is only along the shores of continents, where subsidences have occurred and the sea has temporarily overflowed the land, and left groups of sediments as records of such invasion, that we find the history broken into chapters. But such subsidences and deposits were not synchronous in different parts of the world, therefore the succession of strata on each continent must be studied by itself. Even here the phenomena are local, not general; the successive subsidences which resulted each in its circle of sediments were not conterminous, nor equal measures of time. The physical evidences of these changes are much more strongly marked in some places than others, and locally the faunæ intermingle in such a way as to confuse the lines of demarcation. Hence, the divisions of the geological column must largely be matters of convention, but in this convention stratigraphy should be heard as well as paleontology. In my judgment it will be found most convenient to make chief divisions along lines marked by great physical breaks, and so I would make the Potsdam sandstone, which marks a great physical change over all the North American continent east of the Wasatch—inaugurating a new era—the basal member of the Or-

dovician system. Everywhere this is unconformable with the Cambrian below, but conformable with the Calciferous, Chazy, Trenton, etc., above.

Another change of sediments and unconformity occurs at the Medina, and this inaugurates the Silurian age. Still another is marked by the Oriskany, the natural base of the Devonian, and by the Chemung, which I claim is equally the natural base of the Carboniferous, according to physical history.

The changes of fauna are nearly parallel; the facies of the Cambrian fauna continues into the Potsdam, but the species are all different; so the aspects of the Trenton fauna reach into the Silurian, but out of 10,000 species only about ten pass over.

The subsidences which resulted in the formation of the Silurian (Upper Silurian) and Devonian strata were much more limited in time and area than those in which the Ordovician and Carboniferous systems were produced, but locally the breaks at the Oriskany and Medina are complete. Certainly the classification which makes the Oriskany the upper member of the Silurian and divides the Calciferous to form the top of the Cambrian and the base of the Ordovician is "forcing the balance."

Another argument in favor of adopting the Potsdam, Medina and Oriskany as bases respectively of the Ordovician, Silurian and Devonian is that these were chosen by the New York geologists in framing their standard section, and that choice was confirmed by Lyell and Verneuil. Hence that system of classification has become a part of our geological literature, is most familiar to teachers and students, and could not be exchanged for a new and less tangible and natural system, without confusion, and, I think, more serious evils. Hence, I would say, "better bear the ills we have than fly to others that we know not of."

The commingling of Oriskany and Corniferous fossils at De Cewville, etc., Canada, first described by Billings (Canada Geol. Rep., 1863, p. 359, etc.), and recently investigated by me, renders it impossible to assign these strata to different systems.

As regards the Chemung, I will only say that between the Mississippi and Atlantic this marks not only a great physical break (unconformity), but a great change of fauna as well; the inauguration of the reign of the Productidæ and other Carboniferous forms. Above the Chemung we find perfect conformity, and a gradual change of fauna that makes it impossible to establish any

satisfactory base for the Carboniferous system. My recent studies of the fishes of the Chemung and Waverly have confirmed me in the conviction that the Chemung should be accepted as the base of the Carboniferous.

I enclose a table which embodies my ideas in regard to the classification of our Paleozoic rocks.

In great haste, but very truly yours,

J. S. NEWBERRY.

CLASSIFICATION OF THE PALEOZOIC ROCKS OF NORTH AMERICA SUGGESTED BY J. S. NEWBERRY.

Carboniferous System.

Upper Carboniferous (Coal Group),	Permian. Coal measures. Millstone grit.
Middle Carboniferous (Carb. Limestone Group),	Chester beds. St. Louis beds. Keokuk beds. Burlington beds.
Lower Carboniferous (Chemung Group),	Waverly. Catskill (local, lacustrine). Chemung.

Devonian System.

Upper Devonian (Hamilton Group),	Portage shales. Genesee shales. Hamilton shales and limestone. Marcellus shale.
Middle Devonian (Carboniferous Group),	Corniferous limestone. Onondaga limestone. Scoharie grit and limestone.
Lower Devonian (Oriskany Group),	Cauda-galli grit. Oriskany sandstone.

Silurian System.

Upper Silurian (Helderberg Group),	Upper Pent. limestone. Scutella limestone. Delthyris limestone. Lower Pent. limestone. Water lime. Salina, local, lacustrine.
Middle Silurian (Niagara Group),	Niagara limestone. Niagara shale. Clinton limestone. Clinton shale.
Lower Silurian (Medina Group),	Medina sandstone. Oneida conglomerate.

Ordovician System.

Upper Ordovician (Hudson Group),	Hudson river shales. Utica shales.
Middle Ordovician (Trenton Group),	Trenton limestone. Black river limestone. Birdseye limestone. Chazy limestone.
Lower Ordovician (Potsdam Group),	Calciferous sand rock. Potsdam sandstone.

Cambrian System.

Upper Cambrian,	Taconic group.
Middle Cambrian,	St. John's group.
Lower Cambrian,	Ocoee group (?).

Other Opinions.

Besides these communications, a number of answers have been referred to the sub-committee on the Lower Paleozoic, given in response to the questions O, P, Q, of Dr. Frazer. In addition to those who have already been quoted at length, the following geologists give opinions on the nomenclature of the Lower Paleozoic, viz.: Sir William Dawson, Dr. A. R. C. Selwyn, Professors Le Conte, Irving, G. H. Williams, and B. K. Emerson, and Messrs. Hague, Blake, Macfarlane, S. F. Emmons, and Dutton.

Of these opinions, so far as they relate to the use of the term Taconic, Messrs. Dawson, Selwyn, and Irving think that the term is utterly useless in geological nomenclature. Messrs. Emmons and Emerson say they would follow the conclusions of Mr. Walcott. Messrs. Williams and Le Conte recommend that the term be not used at present, owing to the controversy and confusion attending it. Hague and Blake suggest that it be applied to the strata to which it belongs; and Blake strongly insists upon it. Macfarlane would apply it to some "Pre-Cambrian" rocks, as the *schistes azoiques;* and Dutton thinks its value is still "an open question."

Other answers given by the same gentlemen relate to the manner of division of the "Cambrian," viz.: Professor Dana suggests that the term Cambrian could properly be made to cover all that Sedgwick included under the term, as proposed by some British geologists; that is, the rocks of the first and second

faunas, the greatest physical break in the series of the Lower Paleozoic being at the top of the second fauna rocks. All others would divide the rocks of the first fauna locally, or would follow the classification proposed by Mr. Walcott, viz.: Upper, or Potsdam; Middle, or Taconic; and Lower, or Acadian; the *Upper* including the Potsdam and Lower Calciferous and the Knox and Tonto groups; the *Middle* including the Taconic, Georgia, L'Anse au Loup, and Prospect groups; and the *Lower* including the St. John's, Braintree, New Foundland, Wasatsch, and Tennessee groups.

Respecting the use of the terms Menevian and Ordovician, there is a pretty general concord of opinion, when any is expressed, in the negative; although Messrs. Hunt and Walcott are disposed to regard the term Ordovician as useful and applicable to the second fauna rocks in America, in discussing the relations of the faunas.

Your reporter, therefore, feels bound, regardless of his own convictions, but urged by the opinions of a large majority of all American geologists who have communicated their views to him, and by the known opinion of others, to consider the introduction of the term Taconic in some manner into the nomenclature of the Lower Paleozoic as imperatively demanded in deference to those geologists who have given long study and hard labor to the subject, and who alone should be considered competent to advise.

This step being determined upon, it becomes necessary to decide how and where this term shall be inserted in the stratigraphic column.

It became evident at once that the place for the term Taconic is in connection with the first fauna, and not the second. It would be in violation of a simple and well-known canon of nomenclature to so divorce a term from its original use and definition by its author, that it should have no application to the object described by the author.

It also became evident, on short reflection, that the recommendation of Mr. Walcott, while giving exact justice to Mr. Emmons, in using the term for that part of the Taconic which under his searching scrutiny has yielded an abundant primordial fauna, may be extended as a faunal designation, without injustice to any other claimant, so as to cover the whole primordial zone.

For reasons which were given in a paper which I had the

honor to read before the Committee at the Albany meeting, and in accordance with the suggestions of Prof. James Hall, Prof. Jules Marcou, Prof. C. H. Hitchcock, and Prof. A. Winchell, the term Taconic is made coördinate with the term Cambrian, and they are both applied to well-known faunas, and also to the rocks containing those faunas, in accordance with the design of the authors of those terms.

The scheme of Professor Newberry, while recommending the term Taconic for a prominent part of the primordial fauna, diverges from that of Mr. Walcott in not including the Potsdam [*i. e.*, the St. Croix beds of the following table] in the primordial zone. He, on the other hand, places this sub-fauna, which certainly has a primordial facies, in the Lower Ordovician, which is not in accordance with the idea of the author of the term Ordovician, although it furnishes a coarsely fragmental base for the bottom of the Silurian as he has limited it.

For reasons which the writer has given recently elsewhere,* he is also constrained to recommend, in consonance with the opinions of Professors Hitchcock, James Hall, A. Winchell, Jules Marcou, and Dewalque, of the general committee on nomenclature of the last international congress, and in harmony with the fundamental idea of Mr. Sedgwick, the author of the term, that the term Cambrian be applied to the rocks of the second fauna.

In making the recommendation that the term *St. Croix* be used as a sub-faunal designation, as about equivalent to Mr. Walcott's use of the faunal designation *Potsdam*, it may be well to give the reasons that have actuated your reporter. They are briefly as follows:

1. The fossils embraced in this sub-fauna were described first from the St. Croix formation of the Northwest, and with slight exceptions, so far as they have been found in eastern New York, they are in beds that lie above the typical original Potsdam sandstone, and are embraced in what has been known as the Calciferous sandrock.

2. It is true that Professor Hall and also Dr. D. D. Owen at first placed these fossils conditionally in the horizon of the New York Potsdam sandstone, although no fauna at all comparable to them had then been found in that sandstone. Their authority was followed by nearly all geologists, and the sandstones of the

* American Geologist, March, 1888.

upper Mississippi valley have been known widely as the equivalent of the Potsdam sandstone.

3. In 1872 the writer called attention to the discrepancy in this supposed parallelism and suggested the name *St. Croix* for the fossiliferous formation that had furnished the so-called Potsdam fossils, and has also since then shown the fact that this group of fossils, while pertaining to the upper part of the primordial zone, is not found at all in the true Potsdam horizon, but pertains rather to the succeeding epoch.

4. Recognizing the discordance between the fauna of the true Potsdam of New York and some fossils found in the Calciferous of the same State, but their alliance with the fauna of the so-called Western Potsdam, Mr. Walcott in a published paper called attention to the alliance that thus was shown of the Calciferous of New York with the so-called Potsdam of the Northwest.

5. Since that time much more evidence has appeared, published both by Mr. Walcott and by Mr. Dwight, which has confirmed the opinion of the writer published in 1872; and this goes to demonstrate that the fossils of the Western so-called Potsdam are distributed mainly through strata that lie above the New York Potsdam sandstone, and principally in the recognized Calciferous sandrock.

6. Further, this sub-fauna was discovered in Canada by Mr. Billings. He placed it in the Quebec group, which he supposed was between the Potsdam of New York and the Calciferous, but embracing much of the Calciferous.

7. There is a great sandstone-quartzite formation comparable to the New York Potsdam lying below the St. Croix beds, found in Wisconsin and Minnesota separated from the St. Croix beds by a great unconformity. This great formation plays a conspicuous part in producing the marked topographic features of several places in Wisconsin and Minnesota.

8. Professor R. D. Irving, late of the Wisconsin geological survey, placed the principal fossil-bearing stratum of the St. Croix beds, under the name "Mendota limestone," in the Lower Magnesian (Calciferous) horizon, considering that it was no part even of the St. Croix [so-called Western Potsdam] beds, but that the Potsdam is represented by some lower sandstone.

9. The result has made it apparent that by the use of the term Potsdam for this sub-fauna the two terms come into direct colli-

sion on the classic ground of eastern New York. The term Potsdam, which, on stratigraphic principles, has, in New York, a well-characterized upper limit and an easy identification, claims, on the paleontological evidence that comes across the country from the Northwest, also much of the strata which have been known long as Calciferous sandrock.

10. It is hence obvious that this sub-fauna should not be designated from the Potsdam sandstone.

11. It is equally obvious that the only appropriate designation is that of St. Croix, where it was first worked out, and also where it was first distinguished as a fauna not appertaining to the Potsdam.

Résumé of the Foregoing Considerations.

1. It is necessary to choose designations for *faunal* distinctions based on dominant types of animal life that have succeeded each other with approximate synchronism over large parts of the earth. These names will include in their scope large groups of strata, and should rank as *systemic* in the scheme of geologic nomenclature, as recommended by the Director of the U. S. Geol. Survey.

2. It is necessary to choose designations for the structural, or lithological differences which the rock-masses present. As the lithology varies from place to place, the names chosen for these lithologic phases must be of lower rank, or *serial order*, in the scheme of nomenclature.

3. So far as the names chosen by the New York Survey will supply those designations, both faunal and structural, they should be employed in the system of nomenclature chosen, unless for the faunal names some perfect parallelisms were applied at prior dates in foreign countries.

4. Current American opinion requires the use of the term Taconic for some part or the whole of the strata of the first fauna.

5. Current American opinion is not in favor of the adoption of the European terms Menevian and Ordovician.

6. The Potsdam sandstone of New York does not contain the fauna that Mr. Walcott assigns to the Potsdam sub-fauna; but this fauna is found in the Calciferous sandrock of New York, and in the St. Croix beds of the Mississippi valley. The change here suggested simply adjusts the nomenclature with the facts.

Conclusion.

In consonance with these views and recommendations your reporter would present the following scheme:

The whole of the strata included between the Devonian and the Archean would thus fall into three great groups.

Silurian.
Cambrian.
Taconic.

Under the term *Silurian* fall the American strata known as:

SILURIAN.

Faunal (systemic) designations.		Rock masses of New York. Serial designations, based on structure and physical breaks.
Silurian—3d Fauna.	Sub-Faunas.	
	Lower Helderberg.	Lower Helderberg limestones and Salina shales.
	Niagara.	Niagara limestone and shale.
	Clinton.	Clinton limestone and shales. Medina sandstone and shales.

Under the term *Cambrian* fall the

CAMBRIAN.

Faunal (systemic) designations.		Rock masses and structural designations of New York.
Cambrian—2d Fauna.	Sub-Faunas.	
	1. Lorraine.	Lorraine [Hudson River] shales and limestones.
	2. Utica.	Utica shale.
	3. Trenton.	Trenton limestones and shales, Bird's Eye, Black River and Chazy limestones. Upper part of Calciferous sandrock.

And under *Taconic*

TACONIC.

Faunal (systemic) designations.		Rock masses of New York and New England. Stratigraphic designations.
Taconic—Primordial or 1st Fauna.	Sub-Faunas.	
	St. Croix.	Lower portion of the Calciferous sandrock of New York. The St. Croix beds (so-called western Potsdam) of the Mississippi valley.
	Taconic.	The Georgia group. The Taconic black slate and granular quartz.
	Acadian.	Paradoxides beds of Braintree, Mass., and St. John's Group of New Brunswick.

All other designations and localities as given by Mr. Walcott.

The faunal designations corresponding to these should be taken from the dominant types of life which they embrace, or from the sub-group which gives character to the group. The faunas here represented are nearly those defined and named by Barrande, 3d, 2d and 1st faunas, and at present these terms might be employed, were it not apparent that they may by and by become inappropriate owing to the discovery of faunas that preceded the "first fauna."

Hence your reporter suggests the following:

The Silurian group characterized by the 3d fauna.

The Cambrian group characterized by the Cambrian or 2d fauna, with sub-faunas to be determined.

The Taconic group to be characterized by the 1st or Primordial fauna, with the sub-groups

St. Croix.
Taconic.
Acadian.

This can be seen in the following condensed table:

Rock Masses.	Faunas.
Lower Helderburg. Salina. Niagara.	*Silurian*, or Third Fauna. Sub-faunas, Lower Helderberg, Niagara, Clinton.
Lorraine. Utica. Trenton. Chazy.	*Cambrian*, or Second Fauna. Sub-faunas, Lorraine, Utica, Trenton.
Calciferous. Potsdam. Taconic. St. John's.	*Taconic*, or First Fauna. Sub-faunas, St. Croix, Taconic, Acadian.

With slight exceptions the nomenclature recommended herewith is the same as that offered by Mr. C. D. Walcott, the variations from his plan being those which do not pertain to any paleontologic questions, but to physical structure and to the value of historical evidence.

These variations consist (1) in the enlargement of the rank of the term Taconic, as a faunal term, so that it becomes synonymous with Barrande's term *primordial*, and (2) the use of the term St. Croix as a sub-faunal horizon instead of that of Potsdam.

In recommending the term Taconic as a faunal horizon in place of the term Cambrian, the latter reverts to the position where, as a faunal designation, Messrs. Sedgwick and McCoy define it, viz., to the second fauna, and the Taconic becomes essentially what Dr. Emmons claimed for it, viz., a fauna below the Champlain.

Respectfully submitted,

N. H. WINCHELL,

Reporter on the Lower Paleozoic.

MINNEAPOLIS, March 24th, 1888.

NOTE.

At the request of the editor, Mr. C. D. Walcott has made a collection of paragraphs from his interesting memoir in the March, April, and May numbers of the *American Journal of Science* (1888), on the "Taconic System of Emmons," which in his opinion presents a fair synopsis of his final conclusions.*

Synopsis of Conclusions of Mr. C. D. Walcott on the "Taconic System of Emmons."

The nomenclature employed in classifying geologic formations and terranes should be based upon priority of definition and upon the accuracy of the original observations; the latter to be judged by the testimony of the formations within the areas where they were first made. If the original proposer of a name bases it upon such errors of observation and interpretation that subsequent observers cannot verify his work, and the name can only be used by dropping a name proposed as the result of accurate observation and definition, the latter should be retained.

I endeavored to make, in 1886, an argument for the use of the name Taconic for the Middle division of the Cambrian System, but it failed in the light of later results of field work; and now I think that geologic nomenclature will be benefited by dropping the name entirely. Based on error and misconception originally, and used in an erroneous manner since, it serves only to confuse the mind of the student, when applied to any formation or terrane. There are several reasons for the foregoing conclusions that perhaps it is best to here state.

1st.—The name is not applicable. The Taconic range, from which the "Taconic System" was named, is not known to

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* He says in a note accompanying these excerpts:

U. S. Geological Survey,
Washington, D. C., May 26th, 1888.

Dr. Persifor Frazer, 201 South Fifth Street, Philadelphia, Pa.

My Dear Sir: I have put together the paragraphs you mention in your letter of the 24th inst., and added two others for your consideration. This must not be considered as a report from me, but simply as a suggestion to you.

* * * * * * * * *

Truly yours,
CHARLES D. WALCOTT.

N. B.—The slips (3 pages) are herewith enclosed.—W.

contain a fossil of the first fauna or a formation that contains one elsewhere. The "Upper Taconic" slates lie west of the range, and the "Granular Quartz" series east of it; and the range is formed of strata of the Trenton-Hudson Terrane.

2d.—The "Taconic System" was considered pre-Potsdam on two suppositions: (*a*) that the Calciferous sandrock of the Lower Silurian is unconformably superjacent to the Taconic slates on the west; (*b*) that the variation of the lithologic characters of the Lower Taconic rocks, from the New York Lower Silurian, indicates a distinct system of rocks. We find that the unconformity (*a*) was based on errors of field observation, and (*b*), that the "Lower Taconic" rocks are of Lower Silurian age, with the exception of the lower quartzite, which is Cambrian and *conformably* subjacent to the Lower Silurian.

3d.—The claim of priority of discovery of the Primordial fauna is invalidated by the fact that the fossils found in the Taconic slate were referred to a pre-Potsdam horizon on an erroneous interpretation of the stratigraphy and not from comparison with a known fauna that had been stratigraphically located in any clearly defined geologic section.

4th.—It is only a fortunate happening, and not a scientific induction based on accurate stratigraphic or paleontologic work, that any portion of the "Taconic System" is found to be where Dr. Emmons placed it.

5th.—The application of the principles stated at the beginning of this paper rules out the name Taconic from geologic nomenclature.

6th.—The term Cambrian antedates Taconic for a stratigraphic system, and, also, as a correctly-defined faunal definition.

It was stated under "Discussion" that Professor Dana held the opinion that the "Lower Taconic" was the typical "Taconic System" as first defined in 1842, but as that was proven to be Lower Silurian in age, the "Taconic System" could not longer be recognized.* For a time I was inclined to disagree with this view, but as I approach the end of this investigation I am convinced, after a full consideration of all the circumstances, that the position taken by Professor Dana is the correct one.

The first published section of the "Taconic System" gives *all*

* American Journal of Science, III. vol. xxxi., pp. 241–244, 1886.

the rocks included within it in 1842.* The gneiss is represented on the extreme east and the "Taconic slate" on the extreme west and the "shales of the Champlain group" as resting unconformably on the "Taconic slate." This section includes *all* the strata of the "Taconic System," as then known to Dr. Emmons, and agrees with the description, in the accompanying text, of the rocks of the System.†

As is mentioned in the 1st reason given for rejecting the name Taconic, there is not a known stratum of rock in the Taconic range that is of the geologic age assigned to it by Dr. Emmons.

In 1844 he incorporated a great series of slates and shales belonging to another geologic system by extending his sections across the western belt of the Hudson Terrane, that limited the section of 1842, and on the west to the next line of outcrop of Lower Silurian rocks. This addition gave the opportunity to separate off the "Upper Taconic" in 1856. I have shown that all his reasons for calling this series pre-Potsdam were based on errors of stratigraphy; and that it was a fortunate happening that any portion of the "Upper Taconic" rocks occur where he placed them in his stratigraphic scheme. Even if there were no errors to vitiate Dr. Emmons's argument for the pre-Potsdam position of the "Upper Taconic," that portion of his system could not retain the name "Taconic;" for it belongs to a different stratigraphic system from that to which the strata of the Taconic range belong, and to which he gave the name "Taconic."

The following tabulation of the successive phases of the Taconic system viewed in the light of present facts is instructive. It was proposed in a letter from Professor Dana to the writer:

PHASE I., 1842.

*		"Taconic System,"	True order begins.
	6.	Stockbridge limestone,	II. Lower Silurian limestone.
	5.	Magnesian slate of Graylock,	III. Hudson slate.
		Granular quartz,	I. Cambrian.
	4.	Limestone,	II. Lower Silurian limestone.
	3.	Magnesian slate of Taconic mountains,	III. Hudson slate.
	2.	Sparry limestone,	II. Lower Silurian limestone.
	1.	Taconic slate,	III. Hudson slate.

* Geol. N. Y., pt. 2, p. 145, Fig. 46, 1842.
† Loc. cit., pp. 144, 145.

PHASE II., 1844.

5.	*a.* Black slate. Fossiliferous, .	I.	Cambrian.
	b. Taconic slate, " .		Mostly Hudson slate.
4.	Sparry limestone, ...	II.	Lower Silurian limestone.
3.	Magnesian slates, ...	III.	Hudson slates.
2.	Stockbridge limestone, . . .	II.	Lower Silurian limestone.
1.	Granular quartz, ...	I.	Cambrian.

PHASE III., 1855.

I.	*Upper Taconic.*		
2.	Black slate, ...	I.	Cambrian.
1.	Taconic slate, ...	III.	Mostly Hudson slate.
II.	*Lower Taconic.*		
3.	Magnesian slate, ...	III.	Hudson slate.
2.	Stockbridge limestone and Sparry limestone, ...	II.	Lower Silurian limestone.
1.	Granular quartz, ...	I.	Cambrian.

CLASSIFICATION OF NORTH AMERICAN CAMBRIAN ROCKS.

In the classification of the fossiliferous sedimentary rocks of all countries it becomes more and more evident that the great systems—Cambrian, Silurian, Devonian, etc.—must rest on the broad zoologic characters of their included faunas and not on stratigraphic breaks between the systems, and that geologists will need to recognize the fact so well stated by Lapworth, that "we have no reliable chronological scale in geology but such as is afforded by the relative magnitude of zoological change—in other words, that the geological duration and importance of any system is in strict proportion to the comparative magnitude and distinctness of its collective fauna."* In pursuance of the above principle I have separated the Cambrian System in North America from the Lower Silurian. In the magnitude of sedimentation and extent of the fauna it ranks with the other great geologic systems, and we cannot unite it with the Lower Silurian except from reasons that, if followed out, will unite all the systems from the Cambrian to the Quaternary.

In arranging the different strata composing the Cambrian System three primary divisions are distinguished by the predominance in each of a fauna that, in assemblage of genera and species, may be separated from others whenever two or more of them occur in the same stratigraphic section. This extends to the identification of the relative geologic horizon by the fauna

* Geol. Mag., vol. vi., p. 3, 1879.

when its vertical or geographic connection with other faunas is not preserved. The three divisions of the table have been recognized to a greater or less extent in all the sections of Cambrian strata studied in North America, and all the observed Cambrian faunas come within their limits.

The second column in the table gives local names that have been applied within certain geologic provinces, where the fauna and the sedimentation indicate a greater uniformity of conditions than existed throughout the larger areas outlined by the first three divisions. The right-hand column gives the names of local subdivisions where the conditions of sedimentation and of life were still more restricted.

	Lower Calciferous.	Lower portion of the Calciferous formation of New York and Canada. Lower Magnesian of Wisconsin, Missouri, etc.
UPPER CAMBRIAN.	Potsdam. Knox. Tonto.	Potsdam of New York, Canada, Wisconsin, Texas, Wyoming, Montana, and Nevada; Tonto of Arizona; Knox shales of Tennessee, Georgia, and Alabama. The Alabama section may extend down into the Middle Cambrian.
MIDDLE CAMBRIAN.	Georgia. L'Anse au Loup. Prospect.	Georgia and "Granular Quartz" formations of Vermont, Canada, New York, and Massachusetts. Limestones of L'Anse au Loup, Labrador. Lower part of Cambrian section of Eureka and Highland Range, Nevada. Upper portion of Big Cottonwood Cañon, Cambrian section, Utah.
LOWER CAMBRIAN.	St. John. Braintree. Newfoundland. Uinta?	Paradoxides beds of Braintree, Mass., St. John, New Brunswick, St. John's area of Newfoundland; Lower Portion of Big Cottonwood Cañon, Cambrian section, Utah. Uinta? (The Ocoee conglomerate and slates of East Tennessee are doubtfully included.)

The table is a correlation of the various sections described in the introduction to U. S. Geological Survey Bulletin No. 30, and hence is tentative. It is the expression of my present knowledge and opinion. All who use it in geologic work should refer to the data given in that Bulletin, and decide individually upon the value of the correlations made in the table.

C. D. WALCOTT.

Note on Mr. Walcott's Conclusions.

BY THE REPORTER.

The report on the Lower Paleozoic is based on such facts and opinions as were available at the time it was necessary to present it to the American Committee. Its recommendations, so far as they relate to the use of the term Taconic, assumed that Mr. Walcott's conclusions, since published, would be consistent with his former recommendations, and with the facts which he has more recently brought to light. But, owing to the reversal by him of his conclusions on the propriety of using the term Taconic, it becomes desirable to consider his new views, and the reasons he assigns for his change of opinion.

He says (foot-note to p. 232, Am. J. S., March, 1888) that "the field-work of the latter part of the season of 1887 negatived and rendered obsolete several of the conclusions that he had before arrived at."

A careful examination of his late paper shows this new evidence to consist of the discovery of second fauna fossils on the west side of Mt. Anthony and in its vicinity, "on the line of strike of the Taconic range." They had already been discovered by Messrs. Wing, Dana and Dwight on the western side, and by himself on the eastern side, at points further north and south, and had been given their full significance in the writings of Prof. Dana. But this late discovery is "within the typical Taconic area."

Aside from this no facts are stated not previously known to Mr. Walcott; and with slight exceptions they had all previously been published by him. He does not specify any conclusions previously held by him that have been rendered obsolete by such new evidence: neither is there given in any of his former papers any conclusion that is reversed by this new evidence. Yet, in spite of similar facts long known, and the interpretation put on them by Prof. Dana, Mr. Walcott held in August, 1887, an opinion exactly the reverse, on the main issue, from that which he held in November of the same year, and which he has now set forth.

What may have been the other considerations which have thus induced Mr. Walcott to reverse his opinion he does not state. He simply repeats various criticisms which have been made before

on the work of Dr. Emmons, and concludes that the mistakes the latter made in the minor stratigraphy are so grave and so numerous that it is only a "fortunate happening" that any part of the Taconic strata prove to be what Dr. Emmons claimed.

The paper, therefore, does not affect in the least the merits of the Taconic system as they stood in August, 1887. It leaves the essential elements, and all the facts, as they were, and does not disturb the conclusions of the foregoing report. It embodies numerous arguments, and Mr. Walcott's personal judgment at the time of writing. These have all been considered by some other geologists, and by Mr. Walcott himself prior to November, 1887, as insufficient against the main claim of Dr. Emmons.

To the arguments urged by Mr. Walcott against the use of the term Taconic, and summarized by him (see *ante*), it may be said:

First Proposition. This was known to Mr. Walcott prior to November, 1887, as fully as since, on the statements of Prof. Dana and others.

Neither is the Taconic range known *not to contain* a fossil of the first fauna. The Taconic range is not a single ridge, but a series of ridges and hills, some of the spurs and isolated peaks being so far separated east and west that they embrace different strata. Bird Mountain, in the central part of Ira, Vermont, consists of "quartz conglomerate," partaking of the characters of the "Red Sand-rock Mountains," a name that was applied to the northern extension of the Taconic mountains in 1861 by the geologists of the Vermont Survey (*Report on the Geology of Vermont*, vol. ii., p. 895). The range extends from Canada to Dutchess County, N. Y. It is too broad an inference from a few facts to exclude the first fauna rocks from the whole Taconic range. But a small part of those mountains has yet been examined; and, if the "Red Sand-rock" extension be still regarded as a part of the Taconic range, the fossils of the *Georgia formation* are found in it. That it is right to include these northern hills in the Taconic range is shown by the fact that it is consistent with all Dr. Emmons's topographic, as well as his geologic, work. The "granular quartz" hills also are spurs of the Taconic, and are embraced in the Taconic range in Williamstown, Mass. Such are "the mountains northeast of Williams College," Oak Hill, Stone Hill, and others that occur further north—isolated quartz

knobs that rise irregularly in the midst of the "Hudson-Trenton" terrane (*Agriculture of New York*, p. 86). More than this, the central and principal body of these mountains has not been examined at all—that portion lying in the eastern part of Columbia County, N. Y. Again, it is a striking agreement with Dr. Emmons's description, restricting the range to a single ridge, according to Mr. Walcott's idea, that the first fauna rocks "*lie along both sides*" of that ridge.

Place in juxtaposition with the foregoing the following statement of Mr. Walcott (p. 242). "Fossils occur more or less abundantly at over one hundred localities as now known to me, within the typical Taconic area, and they are distributed at various horizons throughout the 14,000 feet or more of strata referred to this terrane." That is, primordial fossils are found in over one hundred localities in the typical Taconic area, in some of the strata of the Taconic system of Dr. Emmons, in a terrane that is sub-Potsdam.

Second Proposition. These facts were known to Mr. Walcott prior to November, 1887, as fully as since.

These minor errors in the method of investigation did not affect the correctness of the main result, a result the priority of which was approved by Messrs. Billings and Barrande, and accredited by them to Mr. Emmons. Dr. Emmons also represented, as further proof of the unconformity of the Taconic rocks with the Champlain, that the blue limestone (Mr. Walcott's Trenton-Hudson terrane) is unconformable upon the Taconic, and this unconformity Mr. Walcott seems to have accounted for by an assumed "faulting in between the Taconic," the fault-planes being "inclined to horizontal" (p. 400, Am. J. S., May, 1888).

Third Proposition. This argument was as patent to Mr. Walcott prior to November, 1887, as since.

On the other hand, Dr. Emmons did call attention to the fact that these primordial fossils were unlike any in the Champlain division, and, as it was not possible they could be more recent, he inferred, both paleontologically and structurally, that they belonged below the Potsdam. He distinctly states that he regards the black slate as the uppermost member of the Taconic. At that date there had been no publication of "a clearly defined geologic section," containing the primordial fauna.

Further, this reasoning would deprive Columbus of the credit of discovering America. He "blundered" upon it. He expected to strike India. A great many important discoveries would be accredited to persons now unknown, or would have no authors, if the real discoverers were to be held responsible for the minor mistakes through which they passed.

Fourth Proposition. This statement could have been made before November, 1887, as appropriately as since. Nothing new bearing on the position Dr. Emmons assigned the various members of the Taconic, has come to light since November.

That Dr. Emmons made some mistakes in assigning the various parts of the Taconic to their places, is abundantly proved; but that he *only* made mistakes, and that every assignment he adopted was only the result of "fortunate happening," when found correct, we cannot believe. Even Mr. Walcott would not deny that Emmons put the Granular Quartz correctly on the gneiss, and unconformable with it, on correct observation; and Mr. Walcott's own work has proved that the most of the Upper Taconic was correctly placed by Emmons below the Potsdam of the New York system.

Fifth Proposition. These principles were just as forcible prior to November, 1887, as since.

The rule on which Mr. Walcott seems to rely to exclude the term Taconic, will be found at the commencement of his synopsis.

With the exception of minor mistakes which Dr. Emmons made, there is nothing in the results attained by Mr. Walcott which fails to be identifiable with those attained by the founder of the Taconic system. The main result, in each case, that upon which the central and essential element of the Taconic depends, is fully established by Mr. Walcott, viz., *within the typical Taconic area there are sub-Potsdam fossils at over one hundred localities.* No scientific fact could be more accurately verified by "subsequent observers."

Sixth Proposition. This statement is based on history, and must have been equally correct prior to November, 1887, as at any time since.

But in order to antedate the Taconic as a faunal definition Mr. Walcott must deny Mr. Emmons the credit of his announcement of primordial fossils in 1844. Mr. Walcott regards the publication in 1844 as not establishing a valid claim, because the fossils

were not referred to the primordial zone by means of comparison with some well-known standard. *There was then no known standard.* Mr. Barrande's *Notice Préliminaire* was not issued till 1846. The only standard available was the Champlain division of the New York system, and at that date nothing very definite was known even of that group concerning its paleontology. Mr. Emmons did everything that could be done to establish the horizon of the trilobites he described. He placed them in the Taconic, and the Taconic he placed below the Potsdam. It is not just to exact of the pioneer geologists that full and thorough work which is performed under the rules and methods of the present. This priority, moreover, was fully recognized by Mr. Barrande, as soon as he obtained copies of the reports of Dr. Emmons, and he immediately announced it to the Geological Society of France (*Séance du 4 février*, 1861).

The dates of publication of the terms Taconic, Cambrian, and Primordial, may be tabulated as follows (*Amer. Nat.*, Aug., 1887).

	Used as a faunal designation.	Used in geological literature.	Used as the name of a zone or system.
Taconic,	1844	1819	1842
Cambrian,	1853	1836	1836
Primordial,	1846	1846	1846

The foregoing remarks on the late results of Mr. Walcott are demanded at this place, because of the importance of the investigation which Mr. Walcott has been engaged in, and because the recommendations of the body of report B were based largely on his first-stated opinions. It was deemed best to give a full expression of these views, and to weigh the new evidence on which they were founded.

N. H. WINCHELL,
Reporter.

MINNEAPOLIS, MINN., May 18, 1888.

THE

AMERICAN GEOLOGIST

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Report of the Sub-Committee on the Upper Paleozoic (Devonic).

HENRY S. WILLIAMS,
REPORTER.

§ 1. THE NAME.

THE name "Devonian system" was first proposed by Sedgwick and Murchison, in 1839, in an article in the Transactions of the Geological Society (2d Series, 5th vol. pp. 688, etc., see p. 701, published in 1839, and read April 24th, 1838), entitled "On the Physical Structure of Devonshire and the Subdivisions and Geological Relations of the Older Stratified Deposits, etc."

This system, as originally conceived, included a series of deposits found in North and South Devonshire and Cornwall, which thoroughly covers the Devonian system as now understood.

In 1841, Professor John Phillips published his "Figures and Descriptions of the Paleozoic Fossils of Cornwall, Devon and West Somerset," in which are represented some of the more characteristic fossils of the Devonian system, from the lower, Lynton zone to the higher transition rocks of the Carboniferous. The rocks and fossils thus described have become the typical representatives of the "Devonian system," and the works above alluded to are the classical authorities for this system as used by geologists throughout the world.

It was not until about the year 1841, that the literature of American Geology began to show the effects of the masterly classification proposed by Murchison and Sedgwick, for the Paleozoic rocks of Great Britain.

In the fifth annual report of the New York State Geological

Survey, 1841, T. A. Conrad gave a classification of the New York rocks, in which the formations above the Onondaga limestones and below the "Old red sandstone" are considered as equivalent to the upper Silurian of Murchison (see l. c. pp. 31 and 43), referring to the "Old red sandstone" or "Devonian" only the "Chemung" and "Catskill groups" of our modern classification. In the final report (1842, for the 3d district, p. 13), Lardner Vanuxem proposed the name "Erie Division" (of the New York system) for the series of deposits called upper Silurian by Conrad, but added to them the Chemung group. His "Erie Division" included the "Marcellus shales, Hamilton group, Tully limestone, Genesee slate, Portage group, Ithaca group, Chemung group." (See l. c. p. 13.) On page 171 of this report, Mr. Vanuxem states that the last three groups, *i.e.*, the Portage, Ithaca and Chemung groups, "appear to correspond with the Devonian system of Phillips." In the final report for the 4th district, 1843, Professor James Hall adopted the same classification, but expressed the opinion that the Devonian system of Phillips should include also "a portion of the Hamilton." (See l. c. p. 20.) To appreciate this point, it must be remembered that at that time, 1843, the Hamilton group was regarded as the upper measure of the Silurian. In 1846 (Paleontology of New York, vol. 1, p. xvii), Professor Hall first announced the opinion that "from a paleontological point of view the deposits down to the Oriskany should be included in the Devonian." Thus the term Devonian became established in the nomenclature of American Geology.

Although the precise boundaries, both above and below, have suffered some modifications with increasing knowledge, the Devonian system of Sedgwick and Murchison was shown to be unmistakably present in American rocks by the identity or close relationship of the fossil species found therein.

The name "Erian" was proposed by Sir William Dawson in 1871, as an equivalent for Devonian as used in America. (Report of the Geological Survey of Canada: On the Fossil Plants of the Devonian and Upper Silurian of Canada, by J. W. Dawson, 1871, part 1, p. 10.) The name is proposed "for the great system of formations intervening between the upper Silurian and the lower Carboniferous in America." The term "Erian" was an adaptation of "Erie Division" early adopted

by the New York geologists, and the outcrops of the system about Lake Erie, mainly in New York and Canada, were adopted as the typical expression of the system.

The completeness and fine representation of sections and of both faunas and floras in this typical American series, make it a more satisfactory representative of the Devonian system than the original area in Devonshire and Cornwall.

Although the two names "Erie Division" and "Erian" are much alike, they are not used alike. In the New York system as formulated by Lardner Vanuxem in the final report on the Geology of New York, 3d division, 1842, pp. 13 and 16, the "Erie Division" included the Marcellus, Hamilton, Tully, Genesee, Portage and Chemung stages. All below the Marcellus down to the Niagara, was called "Helderberg series" or "division." The Catskill was placed in a separate "Catskill division."

The Erian (*Dawson*, 1871).

	New York and Canada West.	Gaspé.	Southern New Brunswick.	Maine.
Upper Devonian or Erian.	Chemung Group.	Upper Sandstone, Langdon, etc.	Mispec Group, Shales, Sandstones, Conglomerates.	Perry Sandstone.
Middle Devonian or Erian.	Hamilton Group.	Middle Sandstone, Bois Brulé, Cape Oiseau, etc.	Little R. Group, including Cordaite shales and Dadoxylon Sandstone.	
Lower Devonian or Erian.	Corniferous and Oriskany Groups.	Lower Sandstone, Gaspé Basin, Little Gaspé, etc.	Lower Conglomerates.	

The "Erian," as proposed by Dawson, 1871, includes also the Carboniferous and the Oriskany formations of Vanuxem's Helderberg division; but it agrees with the Erie division of Vanuxem, and differs from the accepted application of the Devonian system in New York in excluding the "Upper Catskill group" or "Catskill sandstones." Dawson's Erian is not strictly a synonym for the Erie division of the New York Geology, nor for the Devonian system, as it is generally adopted in American Geology; and as it was proposed as a substitute for the term

Devonian some thirty years after the latter was defined, it is not likely to take the place of Devonian, unless it can be shown to be an advantage to have a different nômenclature for the Geology of each continent.

On the preceding page is a table of the classification and of the typical sections of the Erian as given in the above-mentioned paper, p. 11.

§ 2. The Devonian Areas of North America.

The sections of the Devonian rocks in North America present at least four distinct types of stratigraphy in their outcrops in different parts of the continent. The four areas blend somewhat at their borders, but in their central sections are very distinct.

The four areas may be called the

(1.) *Eastern Border Area,* including the outcrops of Gaspé, New Brunswick, Maine, and other places in Northern New England;

(2.) The *Eastern Continental Area,* including the New York and Appalachian tracts as far south as West Virginia, and extending northwestward into Canada West and Michigan;

(3.) The *Interior Continental Area,* typically seen in Iowa and Missouri, extending into Illinois and Indiana, and probably northward toward the valley of the Mackenzie River; and

(4.) The *Western Continental Area,* best known through Hague and Walcott's studies of the Eureka, Nevada, sections.

Each of these four areas presents sections of the Devonian, which in all the details of their stratigraphical, lithological and paleontological composition are different from each other.

The Eastern Border Area.

The typical eastern border section, as seen at Gaspé, is a heavy series of arenaceous shales, sandstones and conglomerates, gray, drab and red in color, of some 7000 feet in thickness. It lies upon 2000 feet of limestone, which holds, in the upper part, fossils of upper Silurian age. These are regarded by Billings as of Helderberg types. The first thousand feet of the sandstone shows a rich flora, and, by some traces of invertebrate fossils, is known to date back as early as the age of the Oriskany sandstone. The first 5000 feet of the sandstone represents the interval from the top of the Silurian to the top of the Chemung series of the New

York section, and the terminal 2000 feet may represent the Catskill series of New York. (See Logan's Report upon the Gaspé section in "Geology of Canada," 1863, p. 390, etc.) The greater part of this section contains very few fossils, and these are mainly plant remains. In the continuation of the Gaspé sandstones on the Bay de Chaleur the lower and upper beds, as I am informed by Sir William Dawson, are not only distinguished by characteristic plants but also by a rich fish fauna resembling that of Scotland, and divisible into a lower zone with Cephalaspis, Coccosteus, etc., and an upper with Pterichthys. On tracing the outcrops westward across Maine and Northern New England, the coral-bearing limestones of the lower Devonian appear, indicating a changed condition of the seas on approaching the old Archean axis on the westward, but the outcrops, as well as the identity of the fossils, are too indefinite to give a clear idea of the relation of this border region to the better known sections south of the Adirondacks and farther west in New York State.

The Eastern Continental Area.

The second area, the eastern continental, is represented typically in New York State. From there it has been traced downward along the Appalachians as far as to West Virginia (the Tennessee section assuming a closer relation to the interior area), and northwestward in Ohio, Canada West and Michigan. On the western side of the Cincinnati axis the section is intermediate, but presents closer relations with those of the interior than with the typical New York section.

In New York, there is a full series of temporary stages of deposition, each having its characteristic lithological composition and each holding its distinctive fauna. The lower Helderberg limestones were followed, in this area, by a deposit of coarse sand which is thicker and more prominent in the eastern and southeastern part of the region, there attaining several hundred feet in thickness, but thins out toward the northwest, and fails altogether, both in the extreme southwestern and in the extreme northwestern extension of the area. This is the Oriskany sandstone, marked by a few large and well-defined Brachiopods. The Oriskany stage is generally more or less calcareous, and runs up into calcareous shales and grits along the northeastern border of the area. These latter are the Cauda-galli and Schoharie grits of

the New York section. They are followed above by the Onondaga and Corniferous limestones, averaging less than a hundred feet in thickness, but reaching three hundred feet in thickness or more, in some parts of New York and in Michigan.

In this eastern continental area there was evidently some relationship between the sandy deposits beginning in the Oriskany, and the calcareous deposits typically represented in the Onondaga and Corniferous limestones; for we find in the northwestern part of the area the sandstones thinning out to almost nothing, while the limestones reach their greatest thickness, and in the eastern and more southern part of the area the sandstones reach their greatest thickness, while the limestone dwindles and in some parts has not been distinguished at all. The limestone is rich in corals, and in some layers has abundant Brachiopods; the latter are types of wide geographical distribution, and, in the more common forms, such as *Strophomena rhomboidalis* and *Atrypa reticularis*, are species of long geological range. Some of the corals, too, have a long range in the western continental section, appearing in the upper part of the Nevada limestone, according to Mr. Walcott.

In New York the next lithological terrane of the Devonian is a series of shales, often beginning and terminating in black and sometimes partly calcareous shales; but in the central part of the section, gray, soft argillaceous shales, temporarily calcareous in places, and holding a rich and abundant fauna, constitute the Hamilton series. The Hamilton also shows tendency to be more calcareous westward and more arenaceous in the eastern outcrops, and the sandstones and arenaceous shales are thicker and predominant in the Pennsylvania, Maryland and Virginia sections, while the argillaceous and calcareous shales are more conspicuous in New York, Ohio, Canada West and Michigan. A thousand feet may be taken as an average for the thickness, including the two terminal black shales, though some of the Appalachian sections double this thickness. In our accepted classification the upper Genesee black shale is grouped with the Hamilton, but, as I have shown elsewhere, there are good reasons for drawing the distinctive line, separating middle and upper Devonian, below rather than above the Genesee shale.

Above the Hamilton series a period of deposition of arenaceous shales and sandstones prevailed all over this eastern area, called

the "Chemung Period" by Dana, and divided into the Portage and Chemung stages. The deposits attain a thickness of two or three thousand feet in New York and Northern Pennsylvania, and farther south are represented by 5000 feet of sandy deposits, coarser toward the top, and with occasional gravel conglomerates, This series of deposits is characteristic of the eastern area, and is not recognized in the central or western areas. It is linked by its flora with the eastern border sections, and by its fauna is recognized as intimately associated with the upper Devonian deposits of North Devonshire in England.

The faunas of the upper Devonian change rapidly in composition on passing westward from the Appalachian ridges, and the pure Chemung type is scarcely recognized west of western New York and Pennsylvania, although some of its species are seen in the Iowa and Nevada sections. Passing into Ohio, Canada West and Michigan, the upper part of the Devonian assumes a distinct type, which is more closely allied with that of the Indiana and Illinois sections. It appears to be a prevalence of the conditions expressed in the Genesee shales and associated Portage shales and sandstones of New York, with the failure of the Chemung rocks and fauna, running up into shales and sandstones of the Waverly and closing with conglomerates. The more eastern sections, after the Hamilton, run up into sandstones, red and gray shales, sandstones of considerable thickness, and conglomerates, and present no trace of any marine fauna intermediate between the Chemung and the Carboniferous. As we approach the Ohio border going westward the Chemung fauna also fails, and the Waverly follows the Hamilton with only the fauna of the black shales intervening.

In the eastern part of New York, Pennsylvania and southward, the coarse sands and conglomerates with red and green shales, prevail after the Hamilton stage, reaching a thickness of 6000 or 7000 feet, and then the Chemung fauna is sparse and confined to the lower strata. This red shale and sandstone type is called the "Catskill group" in New York, the "Cadent series" of the Pennsylvania nomenclature. In the eastern Appalachian area this same lithological type of rocks continues all the way upward to the coal measures; green and red shales, sandstones and conglomerates, and occasionally thin beds of limestone, but with no trace of the marine faunas which characterize the

interval in Ohio, Indiana, and particularly in the interior continental area. In Pennsylvania these rocks have been called "Vespertine Series," "Umbral Series," and "Seral Conglomerates" by the first survey, and "Pocono Sandstone and Conglomerate," "Mauch Chunk Red shale," and "Pottsville Conglomerate" by the second survey, and in central and eastern Pennsylvania they together reach a maximum thickness of nearly 5000 feet. These peculiarities, however, do not extend westward of Pennsylvania and New York. Before reaching that line, in fact, the red shales have nearly disappeared from the total section, and as the Chemung fauna disappears upward, the new Waverly fauna comes in, but only in the border regions between the two areas, are found sections in which both the Chemung and the higher Waverly faunas appear. This Waverly fauna is a transitional fauna and is, in the east, generally associated with the higher Sub-carboniferous marine faunas, and in sections in which the next lower fauna is that of the Hamilton series or Middle Devonian. In the Eureka faunas described by Mr. Walcott, representatives of it are found in the upper Devonian shales ("White Pine Shales") associated with traces of the upper Devonian faunas of the east.

The Central Continental Area.

The central continental area is typically represented in Iowa, Illinois and Missouri, and reaches into Indiana, Kentucky and Tennessee, and possibly far north into British America.

Its prevailing characteristics are calcareous shales and limestones, with some arenaceous admixture at the eastern and southern extremities, terminating in black shales, and rarely exceeding two or three hundred feet in thickness. On the north, east and southeast borders of the area the black shale termination is a conspicuous feature, but in the more central portion, in Iowa and Missouri, the black shale is either entirely wanting or but slightly represented.

In Illinois and Indiana the black shale reaches a thickness of one hundred feet or more, and is immediately followed by the shales and limestones of the Kinderhook, or Knobstone stage holding a fauna closely allied with that of the Waverly stage of Ohio. East of the Cincinnati axis the black shales are first thin; they thicken on going eastward, and distinctly represent

the upper Devonian of Western New York. Including all that is now rated as above the Hamilton shales and below the Bedford shales this upper Devonian of Eastern Ohio is from 400 to 2000 feet in thickness, thinning westward (see Professor Orton's Preliminary Report on Petroleum and Gas, 1887, p. 26).

When we reach the central part of the interior area we find the Devonian represented by limestones running up into fine argillaceous shales, resting on upper Silurian limestones which in numerous places are of Niagara age, and in the southern border of the region are more or less siliceous, and hold fossils of the later Silurian time, as in the *Delthyris shales* of Missouri which are, doubtless, as late as Lower Helderberg time. This central area lacks the black shale and runs up immediately into Sub-carboniferous limestones, calcareous shales and sandstones, and the total representatives of the Devonian are scarcely 200 feet thick.

The Western Devonian Area.

I take the Nevada section of the Eureka district as typical, since this has been carefully developed by the labors of Hague and Walcott (see Walcott's Monograph, Paleontology of the Eureka District, U. S. Geol. Survey, 1884).

The peculiarities of this section are as follows:

Lying unconformably upon a thick series of limestone beds, representing the Trenton and, at the top, the Niagara series of eastern sections, comes the *Nevada Limestone*, 6000 feet thick, indistinctly bedded and siliceous below, and becoming massive toward the top with intercalated beds of shale and quartzite. The same fauna runs from bottom to top, but with some change in part of the species. In the lower 500 feet the fauna is distinctly lower Devonian, and in the terminal 500 feet it is as distinctly allied with the upper Devonian of the east. Throughout, there are found species which in the typical eastern sections are restricted to particular zones. In its species it shows closer relationship with the Iowa Devonian than with the more eastern faunas, containing two species (see p. 265) that have been found far to the north in the Mackenzie River Basin, *i.e. Orthis McFarlanei* and *Rhynchonella castanea* (N. 67° 15′, long. 126° W.). Overlying this limestone is the White Pine Shale, a black shale, estimated at 2000 feet in thickness, running into red and brown-

ish sandstones and arenaceous shales, with some plant remains and a sparse fragmentary fauna which closely resembles in general character the fauna of the similar upper Devonian black shales of the eastern continental area.

In these western sections there is a remarkable difference in the range and habit of species. "Some species," as Mr. C. D. Walcott has shown, "have reversed their relative position in the group as they have been known heretofore, and others have a greater vertical range" (Pal. of the Eureka District, p. 4). Some cases mentioned by Mr. Walcott are *Orthis Tulliensis* at the top, *Orthis impressa* at the base, and several Corniferous corals at the upper horizon (see pp. 4 and 5, etc.).

It is also noticed that the faunas in the higher shales show combinations of Devonian and Carboniferous types (White Pine Shales), but a careful study of the species reveals the characteristic changes of the general fauna that are seen in the eastern sections.

For instance, the new type of Brachiopods belonging to the genus *Productus* (called *Productella* in the New York Reports) begins in this western section with certain small forms typical of the lower and middle Devonian of the east, and it is only in the upper horizon that the larger Chemung types of *Productus* appear. The same thing is seen in the changes in the types of *Spirifera*. The characteristic upper Devonian *Sp. disjuncta* appears only in the upper part of the section as in the east. The peculiarities of this western section in its paleontology, are most readily explained by the assumption, supported also by other facts, that throughout the whole age the deposits of this area were made in a wide, open ocean, with islands, perhaps, but with no great masses of land to disturb the general uniformity of the conditions of life.

The central area was, doubtless, at considerable distance from land but in no great depth of depression. The eastern continental area from Michigan around through Canada, New York and down the Appalachians, must have been during the Devonian age, near enough to shores for the faunas, as well as the nature of the deposits, to be affected by the ocean currents, and to feel strongly the effects of relatively small amounts of change of level between land and water. Here the faunas are both more local and more limited in geologic range, changing more suddenly and fully in their combinations and species. The conditions of the eastern border were those of rough and tempestuous coasts.

Conclusions.

There are thus, 1st, a northeastern border area, mainly composed of coarse, arenaceous deposits, thick, and with little to distinguish it into subordinate zones.

2d. An eastern continental area, with sandstones, limestones, shales and conglomerates alternating with each other, and presenting a rich and varied series of faunas, marking a considerable number of distinct zones which follow in a constant order.

3d. A central continental area, mainly limestone and soft argillo-calcareous shales, and, compared with the more eastern sections, very thin; presenting a fauna which represents the whole eastern Devonian and is plainly a sequent to an underlying upper Silurian fauna. It is followed by a Carboniferous fauna to which it is generically closely related, and about its border is terminated by a black shale.

4th. A western area represented by a thick massive series of limestones followed by black shales, not separated into distinct faunas, but carrying a common fauna showing but slight change from bottom to top.

With all these great contrasts in lithological, stratigraphical and paleontological characters, the evidence is satisfactory that the several sections are representatives of the same geological age; that, taken as wholes, they do not represent parts, the one taking the place of an interval in the other, but they cover approximately the same interval, and probably represent approximately the depositions of the same length of geological time.

They are bound together, and their relationship certified to by the fossils they contain. The relationship is recognized in the combination of species to form faunas and in the varietal modification of species, as well as in the identity of the species themselves. We cannot find stronger contrasts across the Atlantic eastward than are found across the continent westward. The principles which the American geologist is required to apply in discussing the geology of his own domain are no less broad than those which the International Congress meets with when it attempts to unify nomenclature for all the world. Wherever unification is practicable in America it is practicable for all the world, and where America finds unification a cumbrance it is useless for an International Congress to attempt it.

What is there in the Devonian system, as represented in North America, which demands uniformity of nomenclature, and wherein will attempts at uniformity in nomenclature either strain or misrepresent the facts?

1st. It is perfectly clear to a paleontologist studying the faunas and floras, that the system under consideration, in each of the so dissimilar types, is the representative of the Devonian system of Great Britain, Belgium, Germany and Russia, in all the central features of its marine and brackish invertebrate, and vertebrate faunas; and in its floras. That the name Devonian, as the first name used, should be applied to this system of rocks, we see no reason for dispute.

2d. In all the sections, in so far as they exhibit it, the order of sequence in the modification of faunas is the same, and this sequence as presented in foreign sections is found to follow the same order, wherever species are identical, or are closely allied varieties of the same type; their place of dominance in the series is the same for each section, but the range may vary; in one area species may be restricted in range; in another, species may range through a long series of deposits. In other words, species which are found to have a world-wide distribution, although in one area they may be restricted to a particular stage of the Devonian, are likely to have a long geological range in other areas, not less than from bottom to top of some complete Devonian sections. But a particular combination of species, forming a characteristic fauna of a special stage in one area, occurs at the same relative position in any other area in which it appears. Such faunas are, however, actually more or less local, and, as far as the Devonian is concerned, it is not practicable to form more than three subdivisions of the Devonian to which to apply universally uniform names. These three, in their general typical faunas, can be recognized (so far as they are present) in the different areas of America and Europe, the lower, typically seen in the Corniferous limestone of New York; the middle, represented in the Hamilton fauna of New York; the upper, represented in the Chemung fauna of New York. Any attempt to unify in the finer details is useless for America, and, of course, would be useless if attempted for all countries.

3d. In the sections of America alone there is found nothing in

lithological composition or sequence which is uniform for the several areas.

In seeking uniformity of nomenclature the study of the American Devonian leads to the following conclusions:

(1) That uniformity is desirable in the names and prominent distinctive biological characters of the so-called systems.

(2) That valuable results may be reached by a discussion, on the part of those acquainted with the same system in the different parts of the world, as to the best biological criteria for marking the boundaries of the systems.

(3) That while uniformity is possible in subdividing a system into parts, the number of such parts, and the characters distinguishing them, must be determined after a wide, comprehensive and minute study of their biological characters.

(4) That preliminary work in classifying rocks should not seek uniformity, but should adopt local nomenclature, and that nomenclature based upon an exhaustive comparison of representative sections can alone reach a uniformity that will be of permanent value.

§ 3. The Base of the Devonian.

The precise point of division between the Silurian and the Devonian has not been uniformly determined. After finally adopting the equivalency of the New York Corniferous rocks with the Devonian of English authors—not the Silurian, as was at first thought correct,—the New York geologists placed the base of the Devonian at the top of the Oriskany sandstone. In 1847, De Verneuil, making a comparison of the American geological series with the European, in the Bulletin of the Geological Society of France, urged the propriety of regarding the Oriskany as the base of the Devonian, the chief reason being the appearance in the Oriskany of the first *Spirifers* with bifurcating plications, a common character in the Devonian and particularly in the Carboniferous. In 1859, 3d vol. of Paleontology of New York, Professor Hall objected, and proposed that the Oriskany should be regarded as the top of the Silurian, because the first vertebrates then known in our series were found above in the Schoharie grit.

Neither of these arguments are of any value now, as vertebrates have been found below the Oriskany, and as the type of *Spirifer* referred to by De Verneuil begins in the Niagara (Dana).

The only other point brought forth as decisive is the principle of a cycle of deposits according to which the sandstone would be regarded as the final stage in the cycle.

This base of the Devonian, either faunally or lithologically, applies only to the eastern area. In the Gaspé section the Oriskany fauna has been reported from the upper part of the limestone and as high as 1000 feet up in the sandstone. In the sections of the central area no evidence has appeared either of the faunas or of the peculiar sandstones. Neither in the western continental area has evidence appeared of the Oriskany fauna, and while the base of the Nevada limestone is distinctly siliceous, there is no representative of the Oriskany sandstone of the east.

That a distinct line of separation between Silurian and Devonian is to be found in most sections is clear; this is particularly the division between Lower Helderberg and Corniferous or lower Onondaga limestones; and that Oriskany faunas are transitional is equally clear, but on which side of the line they should be placed is not as clear. By the *Eatonias* and allied types the connection is closer with what goes below;—by the *Terebratuloid* and *Spirifer* types the Oriskany is closely linked with what follows in Devonian. The Fishes and *Merostomata Crustacea* both begin below the Oriskany, and from a faunal point of view would lead to placing the division line as low as the Lower Helderberg series. However, the common usage in America is that which includes the Oriskany in the Silurian, following the precedent set by the New York Survey.

If we look for precedent in the earlier established European divisions, we find little help, since the precise details of the faunas and rocks are wanting on the eastern side of the Atlantic, as they are outside of the Eastern continental area of America. It is more than probable that in future classifications the intervals between like deposits, as two sandstones or two limestones containing distinct though similar faunas, will be found to be a more satisfactory means of subdivision than the sudden passage from sandstone to limestone, from one deposit to another very unlike, although they should bear very dissimilar faunas.

The American treatises on geology, text-books and manuals, generally follow the precedent set by the New York Survey of including the Oriskany in the Silurian. The United States Geological Survey in some of its publications adopts the rule of Oris-

kany at the base of the Devonian. English and European authors more generally follow the latter classification.

§ 4. The Top of the Devonian.

The determination of the top of the Devonian in America is beset with as much difficulty as that of its base,—but for different reasons.

In the eastern border area, the Gaspé and New Brunswick sections, the sands and conglomerates run upward into coarse conglomerates and red sandstones, which by their flora are regarded as the base of the Carboniferous, but there is no sharp distinction in lithological characters to mark a transition. In the Appalachian region, north, east and southward, the transition is lithologically marked by a prominent, coarse conglomerate, above which the flora is Carboniferous. Further west, in western Pennsylvania, there is a Chemung fauna below, followed by a distinct invertebrate fauna, the Waverly, but when the two faunas appear in the same section, as for instance about Meadville, the change is no more marked than the passage from the Hamilton to the Chemung, both members of the Devonian system. Passing further west, in Ohio and Michigan the Chemung fauna is wanting, and in matter of sequence the Waverly fauna follows the Hamilton fauna with its distinct black shale sub-fauna. A black shale appears also above the first stages of the Waverly as well as below it, which contains a fauna closely allied to the fauna of the lower Devonian black shale of New York, the Marcellus.

In the interior continental area, the passage is directly from the Hamilton (a Devonian fauna) to the Kinderhook, Waverly, or Burlington faunas which are recognized as marking the early stages of the Carboniferous system.

In the western Nevada (Eureka) section and Arizona (Kanab), the upper Devonian shales and sandstones terminate with unconformity below the Carboniferous deposits, but in the Utah (Wahsatch) section, there is a continuous limestone (the Wahsatch limestone), the top of which is Carboniferous, while the bottom is regarded as equivalent to the Nevada limestone of the Eureka section. More detailed study of these western sections will doubtless give greater clearness to the stages marked by the faunas, but the absence of coal measures in this western area will make

it necessary to define the subdivisions by means of invertebrate faunas.

From a comparison of the several series of North America it is evident that there are several clearly-defined distinct marine faunas in the Paleozoic. Without considering the lower Silurian, we find three distinct stages of a purely marine fauna: (a) the Niagara, (b) the Hamilton, (c) the Sub-carboniferous, the latter represented typically in its later members, the St. Louis and Chester stages. In the interior basin, where the limestone formations are almost continuous, including all three, these three faunas appear in sequence and can be compared, showing both their differences and their likenesses. Where the same genera are concerned the species are distinctive, but at the same time are so similar as to suggest close relationship. The most distinctive differences in the three faunas are in species or genera found at only one of the stages, and, when we compare these sections with the sections of the east or of the west, we find on the one hand that the sharply-defined faunas are marked by specialized and modified local stages of one or other of these typical faunas. Thus the Corniferous is a coralline modification of the lower Hamilton fauna of the interior; the Chemung is but a specialized stage of the upper Hamilton of Iowa, and the Waverly is but an eastern modification of the lower stage of the Carboniferous fauna of the interior, while in the west there is a blending of the Corniferous, Hamilton and Chemung types throughout a series of several thousand feet of limestones and shales. In the same way the upper Helderberg limestone holds a fauna which appears to be a modified or later stage of the Niagara fauna.

The sharp distinctions are seen in those areas where there was a definite interruption of the conditions of the ocean during the deposition, and the line between the Silurian and the Devonian is sharpest where the Niagara and the Hamilton were neither of them strongly calcareous, but are separated by a limestone followed by a marked sandstone and then a limestone again, as in the Appalachian area. So also at the top of the Devonian, in the same general area, it is the elevation of the bottom expressed by the great accumulation of arenaceous shales, sandstones and conglomerates separating the Hamilton marine fauna from the marine fauna of the Carboniferous, that makes the transition so conspicuous.

In the interior, where there was evidently a marine basin continuously from the lower Silurian to the Carboniferous period, the Niagara, Hamilton and Sub-carboniferous faunas are scarcely more strongly contrasted than the three faunas of the members of the Cambrian system, and had we not such sections as are found in the east, or the precedents of European writers, it is doubtful if any good geologist would have distributed the rocks (for instance, those of Iowa between the Maquoketa shales and the coal measures) into three distinct geological systems of the Paleozoic.

This great difference in the details of the passage from Devonian to Carboniferous in the several sections does not imply that one section is complete, and that where faunas are wanting there was of necessity a gap in the deposition, but rather that the conditions favoring the life of the fauna were wanting in the area where it fails. If our knowledge were complete, it is not likely that any strong separation lines would be recognized between faunas that are alike in widely separated areas.

When we attempt to define the upper limits of the Devonian in terms of marine invertebrate fossils, it can be said that the line is indistinct and the evidence unsatisfactory in the eastern border region. In New York the highest invertebrate marine fauna is that of the Chemung stage. The Catskill stage in eastern New York follows the Chemung fauna in general, but the fact that species of fish and plants which characterize the typical Catskill rocks have been found in strata having Chemung fossils above them, makes it impossible to locate the precise equivalency of rocks marked only by the one or the other of these types of fossils. In Western Pennsylvania the Pocono series, including the Oil Lake stage, the Meadville stage and the Shenango stage of the 2d Pennsylvania Survey nomenclature, as applied by I. C. White (see Report Q. 4), follows the termination of the Chemung fauna, and contains the Waverly fauna of Ohio. In this region there is no true Catskill, but red shales, sandstones and conglomerates follow the zone bearing the Waverly fauna. Hence it is reasonable to conclude that the Pocono and Mauch Chunk of Pennsylvania, as well as the Catskill, the three together reaching a maximum thickness of no less than 10,000 feet, represent an interval in Western New York, between the termination of the Chemung fauna and the base of

the Olean Conglomerate. This interval is filled by barren shales and sandstones, sometimes red and green shales, and in places is but a very few hundred feet in thickness.

In Eastern Ohio the Portage stage of the Chemung series is represented, but the Chemung fauna fails, and the black shale contains the last representative of the Devonian, followed by a Waverly fauna. This is substantially the case in Michigan. Farther west and south, in Indiana, Illinois, Missouri, Kentucky, and Tennessee, the black shale and its fauna may be regarded as terminating the Devonian, the next fauna above being the representative of the Ohio Waverly. Wherever, as in Iowa, the black shale ceases, the Hamilton fauna is the last Devonian fauna, and above it comes the representative of the Waverly in yellow siliceous limestones or yellow calcareous sandstones, of slight thickness. In the sections in the extreme west, no distinct separation of the faunas at the top of the Devonian is reported, but there appears to be a gradual passage into a fauna which resembles our eastern Waverly.

§ 5. The Subdivision of the Devonian.

The subdivision of any great geological system must depend in great measure upon the differences in the faunas or floras contained, and, as I believe, this depends in no small degree upon the geological changes which modified and shifted the geographical conditions under which the animals lived. A sandstone will not contain the same species as a following limestone, and even in arenaceous shales, a slight change in the fineness or coarseness or in the amount of argillaceous mud mixed with the sand, modifies the composition of the fauna contained in it.

Again, we do not need to go outside of the United States to find four entirely distinct sections, each of which represents unmistakably the Devonian system. These may be represented in the Gaspé section, the New York, the Iowa, and the Nevada sections, no two of them presenting any features of resemblance in their lithological composition or order of sequence, and giving, in the organic remains they carry, evidence of entirely different biological conditions, but at the same time by various links of evidence they are believed to represent the same geological age.

It is thus evident that all the divergent conditions (except those of separate language) which might call for heterogeneity of

nomenclature, are met with in the Devonian of North America. On the other hand, if uniformity of nomenclature is desirable anywhere, certainly it should be applied here. But, as we have seen, the physical characters of the stratigraphy, or the lithological constitution of the rocks, are of little or no value in determining the true equivalency of stratified deposits found in distinct geographical areas.

In seeking to determine the place in the column of any newly examined set of rocks, there can be no question that, if they are fossil-bearing, the fossils are the critical tests. Thus we determine that the Iowa Devonian is a representative of middle and upper Devonian of New York, and in the Gaspé series the discovery of *Rensselaeria* in the sandstone 1000 feet above the limestone, leads us to synchronize that horizon with the New York Oriskany. In this way, also, the limits of the Devonian strata in New York were found by a comparison of their fossils with the Devonian fossils of Phillips, or with the Rhenish or Belgian fossils, as was done by De Verneuil. This reveals one usage that is common to us all; in determining equivalency of geological horizon for areas between which there is no known continuity of strata, the fossil contents are the determining criteria. And there is a second rule involved in this operation; in attempting to compare and thus unify nomenclature in the classification of geological deposits, there is a typical section which is taken as the standard, and with it the new sections are compared.

This leads to the consideration that in order to reach uniformity in usage of nomenclature we must first adopt uniform standards. For the Paleozoic, as high as to the top of the Devonian, the New York section is practically the adopted standard for North America. But in the grand divisions, as is evident from the terms Devonian, Silurian, Cambrian, and in the minor subdivisions if we closely study them, there is found a prior standard which has been the basis for classification, if not of nomenclature, in this "New York system."

Taking our example, the Devonian, the influence of a lower, middle and upper Devonian is felt in the classifications of all the Devonian areas in the world. While we are accustomed to take the standard of New York, and to place the termination of the lower Devonian at the top of the Corniferous limestone, and of the middle Devonian at the top of the Genesee shale, this sub-

division of the Devonian does not agree with the English or European usage when analysis of the fossils is carefully made. The most important difference is at the division between the middle and upper Devonian. In both European and British usage, there is a transition from (1) a rich Brachiopod marine fauna typically seen in the Ilfracombe beds of Phillips, the Givetien limestone of Belgium, the Stringocephalien shales or limestones of the Eifel and Hartz regions; to (2) calcareous shales or limestones or, farther north, to sandstones characterized by a peculiar and new *Rhynchonella*, which gives the name to the zone as the *Cuboides* shale or limestone. Above the *Cuboides* zone, in several sections, there follows a black shale with a peculiar *Cardium* (*Cardiola retrostriata*), and in other places, or in the same section, a zone rich in *Goniatites*. Without attempting to prove identity of species, any one acquainted with the fossils from the two sides of the Atlantic, and without criticising the names, would see at once that the series of faunas and their order are found identical in the sections of New York and those of the European continent. Following the Hamilton with its rich, varied fauna, in which *Phacops bufo* plays as conspicuous a part as does the *Phacops latifrons* of the European section, there appears the Tully limestone with *Rhynchonella venustula*, which only an expert could separate from some specimens of the European *Rhynchonella cuboides*. Then comes the black Genesee shale with *Cardiola* (*Glyptocardium*, Hall) *speciosa*, and at the base of the Portage of New York the *Goniatites* peculiarly abundant in places. Following these, in Europe and Great Britain and New York alike, is the typical upper Devonian, our Chemung, English North Devon, and Belgian Famenien and German Condrozien.

Now in the European nomenclature, the Frasnien and its equivalents, which correspond with the Tully (its typical fauna), the Genesee and lower Portage faunas of New York, are all put in the upper Devonian. The division is drawn at the top of the *Stringocephalien*, and below the *Cuboides* zones, which would be at the base of the Tully for us. As a matter of mere interpretation of maps, this means that by our usage of including the Tully and Genesee in the middle Devonian our maps would be interpreted wrongly by Europeans just to that extent. Our representative of the Cuboides zone is certainly in the middle or upper part of the Tully limestone, and the special Tully fauna is dis-

tinct, but there can be no reason whatever for dividing the Genesee from the Portage, for in the typical section recurrences of the Genesee lithological conditions occur up to the very base of the Portage sandstones which terminate the Portage group of the New York system.

If, therefore, we follow precedent and speak of a distinction between middle and upper Devonian, the Genesee shale certainly, and the Tully limestone, so far as its typical fauna is concerned, belong strictly to the upper Devonian and not to the middle; and in order to adapt our usage to the accepted usage of European standards, when speaking of upper and middle Devonian, we should include in the upper Devonian the Genesee shale and so much of the Tully as contains the *Rhynchonella venustula* fauna.

It is to be noted in this comparison with the European expression of the Devonian, that the same general difference observed in comparing the eastern continental with the central area of America is observed in comparing the area of northern Europe with that in the southwestern part. The northern section presents much similarity to the New York section, though with more limestone, until we reach Devonshire, which is more arenaceous than the New York area, and still farther north in Scotland is represented by the old red sandstone, which may be likened to the sandstone part of the Gaspé section. But in Asturia, the Spanish area, according to Barrois the Devonian is mainly limestone, the divisions are less marked, and even the peculiarities observed in the fossils of Iowa as compared with New York representatives are shown, as in the variations of a single type of *Spirifera disjuncta.*

§ 6. Problems for Settlement.

In regard to the Devonian, its nomenclature and classification, we find in the United States that there are three or four problems of general interest concerning which it devolves upon this committee to give an opinion:

(1) *The Name.*—Shall we follow the general usage and adopt the name Devonian system, with the area of Devonshire and Cornwall, England, as the typical area, and the paper of Sedgwick and Murchison as the classical description of what the system is?

(2) *The Limits of the System.*—This involves the determination

of (a) the base, and (b) the summit, and may, as a collateral problem, involve the selection of (c) a standard section for the United States. (a) The base: Of the region described, this problem concerns only the eastern continental area. (In the eastern border region the base is above the top of the limestone, and the sandstones higher up present no sharp line for division. In the central continental area there is a decided gap between the Devonian and the next lower Silurian faunas. In the west there appears to be a gap and unconformity separating the base of the Nevada limestone (Devonian) from the lower Silurian or upper Silurian in places above it.) (b) The top of the Devonian: The question involved here concerns the central and eastern continental areas of the Devonian. The points to determine are as follows:

(1) Shall we include the Catskill rocks (and when no marine faunas occur, up to the base of the Olean Conglomerate and equivalents) in the Devonian?

(2) Shall the Chemung marine fauna be taken as the uppermost marine fauna of the Devonian? Or, shall a part or the whole of the marine faunas between the middle Devonian and the Conglomerate which introduces the coal measures be called Devonian?

I have elsewhere presented the facts which support the view, that if an arbitrary line is to be drawn, faunally, it should be between the Chemung and the Waverly; the only place where they appear to meet in continuous section is in Western Pennsylvania. The difficulties are not less serious in England, and the Pilton and Baggy Point beds of Devonshire hold faunas which it is as difficult to settle on the Devonian or the Carboniferous side as it has been with the Waverly, Kinderhook or Marshall faunas. The fullest discussion of the problems on this point of the termination of the Devonian will be seen in Alex. Winchell's paper on the "Geological Age and Equivalents of the Marshall Group" (Proc. Amer. Phil. Soc., vols. 11 and 12, 1869 and 1870).

But in the New York and Appalachian sections the question is,—Shall the Oriskany be taken as the base of the Devonian or as the top of the Silurian? If we draw lines they must be drawn somewhere, arbitrarily or not. The Oriskany, like the Foreland grits of Devonshire, may be called passage beds or Devono-Silurian, as was proposed by Professor Hull for the Foreland

grits, or we may settle the question, which at present is variously interpreted by American geologists. The use of such combinations helps little; it is merely an expression of ignorance or of imperfection of the classification. The real question is, Shall we draw arbitrary lines, and if so, where in a given standard section shall the line be drawn? It matters little on which side of the Oriskany the line be drawn, but wherever it is put it is better for American geologists to have a uniform usage than to attempt to mediate by saying passage beds, for the same difficulty will be found everywhere in the series, unless there be a gap, or unconformity, and any particular formation may be regarded as a passage bed from the one below to the one above. The New York Survey has set the precedent of placing the Oriskany at the top of the Silurian, from which precedent I have already given reasons for dissenting.

(3) The third problem demanding settlement is as to the division of the Devonian. Do we wish to have a uniform system of subdivision for the Devonian system? This is partly answered by the facts already presented. No stratigraphical or lithological subdivision of the Devonian is possible which shall be applicable to all of the several types of that system in America. Almost the same may be said of faunas, but it is discovered by comparison of sections that the eastern Appalachian sections present the same general succession of faunas as is seen in the English and European sections. Shall we then adopt a trifold subdivision of the Devonian, giving names if necessary, or using merely the general terms lower, middle, and upper, which, as they are arbitrary divisions of the Devonian system, are to be preferred. In the latter case, the top of the Corniferous limestone is the best point of division between lower and middle, and fairly corresponds faunally with European usage. The division between middle and upper, if we seek uniformity with European usage, should be placed below the black shales, the Genesee shale of New York; and where the Tully limestone is present its special fauna should be included in the upper Devonian, as it undoubtedly corresponds with the *Cuboides* fauna of the Frasnien of Belgium and of the base of the upper Devonian of England and equivalent beds, the *Rhynchonella cuboides* being there associated with the *Spirifera* (*Verneuili*) *disjuncta*, which with us, however, does not appear till still higher in the typical Chemung fauna.

Report of the Sub-Committee on Upper Paleozoic (Carbonic).*

J. J. STEVENSON,

REPORTER.

A SUBSTANTIAL agreement as to a general grouping of the Carbonic appears in the communications received, but there is clearly no small difficulty in making subordinate divisions. The enormous area of our country, the distances separating the several regions of Carbonic, and the striking differences in geological conditions, even within the same areas, make the problem as perplexing as that of preparing a general scheme for the Carbonic of all Europe.

The succession of beds is separable into

Upper Carbonic,†

Lower Carbonic,

which in by far the greater part of the country are well defined both physically and paleontologically. The Upper Carbonic is recognized readily in all of the regions, but the Lower Carbonic,

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* Letters of inquiry were sent to those geologists who have spent much time in the study of the Carbonic. Replies have been received from Profs. Cope, J. W. Dawson, Lesley, Newberry, Safford, Smith, Walcott, C. A. White, I. C. White, A. Winchell and Worthen.

† The use of the terms "Upper" and "Lower" has been objected to by many, and rightly enough; but where variations are so great as in the Carbonic, there seems to be no possibility of employing any geographical terms, and the only way out of the difficulty would be the invention of some meaningless names. But the terms "Upper" and "Lower" have been a part of the literature so long that to change them now, without absolute necessity, would not meet with the approval of any.

so very well marked in the Interior Basin and the Appalachian region, cannot be recognized with the same certainty at any but a few localities in and beyond the Rocky Mountains.

THE UPPER CARBONIC.

This contains the Coal Measures, a series manifestly one throughout the Appalachian and the Interior Basin region, where it can be divided, partly on physical and partly on paleontological grounds, into three divisions; while in the Rocky Mountains and beyond, only two have been observed. The exact equivalence of any division in one region with a division in another can not be made out with entire satisfaction, as open sea prevailed westward from the Cincinnati arch, while the Appalachian area was an immense shallow gulf almost closed at the south by converging peninsulas. The marine fauna, therefore, is not of constant assistance—indeed it sometimes leads to contradictory results. The natural divisions for the United States east from the Rocky Mountains, appear to be Upper, Middle, and Lower Coal Measures. Respecting these there is a substantial agreement in all communications referring to the Coal Measures, though there is some disagreement respecting lines of division.

UPPER COAL MEASURES.

Synonyms and Local Subdivisions.

Pennsylvania XIII. in part. Monongahela Series.	XVI.	Upper Barren Group.	Greene Group. Washington Group.	Permian.
	XV.	Upper Productive Group; Upper Productive Coal Group.		

Virginia and West Virginia XVI. XV. } Upper Coal Measures.

Ohio.—Upper Coal Measures.

Indiana. { Merome Sandstone. Upper Coal Measures.

Illinois. Iowa. } Upper Coal Measures.

Kansas. Missouri. } Permo-Carbonic and Coal Measures in part.

Western Regions.—Permo-Carbonic and Upper Carbonic in part.

Nova Scotia.—Permo-Carbonic.

New Brunswick.—Upper Coal Measures.

The well-known Pittsburgh coal-bed has been taken as the base of this division for the Appalachian area. That bed has

been recognized tentatively at several localities within the Interior Basin. If those identifications prove exact, the base will be well-defined throughout.

At the top of the Upper Coal Measures in Pennsylvania, Ohio, and West Virginia, are the beds characterized by a flora containing many Permian forms. These form the Upper Barren Group as given in the table of synonyms. At not far from the same position, apparently, are the beds in Illinois, Texas, and New Mexico, containing reptilian types, which in Europe belong exclusively to the Permian.

The presence of these forms justly leads us to believe that in America the rocks of the Carbonic represent in full the whole series of Carbonic as found in Europe, and justifies us in giving to the upper part of the Upper Carbonic the name of Permo-Carbonic. At the same time this subdivision must be taken only as a part of the Upper Coal Measures and not as ranking equally with it; for the conditions of marine life remain practically the same throughout the whole of the Coal Measures; there being identical forms of fish-life in the upper beds of the Appalachian and of the Interior Basin; while in the latter, as well as in New Mexico and farther west, there is at the top of the column a commingling of Coal Measure forms with a few types which characterize the Permian in Europe. It is sufficiently evident, then, that while the whole of Carboniferous time is represented by deposits in America, there was no such change in conditions as to produce a Permian period or system such as occurs in portions of Europe.

A notable change occurred at the beginning of the Upper Coal Measures which affected vegetable life, for above the Pittsburgh coal-bed, *Lepidodendron* and *Sigillaria* became exceedingly rare, and at most localities they are wholly wanting.

MIDDLE COAL MEASURES.

Synonyms.

Pennsylvania XIII. in part. Allegheny River Series.	{ Lower Barren Group. Lower Productive Group.	{ XIV. XIII.
Virginia. { XIV. XIII. }	Middle Coal Measures.	
Ohio.	{ Barren Measures. Lower Coal Measures in part.	

Indiana.
Illinois. } Lower Coal Measures.

Iowa. { Middle Coal Measures.
Lower Coal Measures in part.

Michigan.—Coal Measures.

Mississippi.
Alabama.
Tennessee.
Missouri. } Coal Measures in part.

Western Regions.—Upper Carbonic in part.—Carbonic in part.

Nova Scotia.
New Brunswick.
Newfoundland. } Middle Coal Formation.

This division is sufficiently well defined throughout the Appalachian area, its floor being the upper sandstone plate of the Lower Coal Measures, while its upper stratum immediately underlies the Pittsburgh coal bed. The Middle Coal Measures is the division of greatest economic importance, and is that which yields by far the greatest amount of coal in all the areas. It has yielded immense numbers of plants and animal remains. The mollusks characterizing it persist in the majority of instances to the end of the Carbonic in the Interior Basin; but they all disappear at the close of this subdivison within the Appalachian area, as thenceforward the conditions within that gulf appear to have been exceedingly unfavorable, for the most part, to animal life.

The separation from the Lower Coal Measures is made largely on physical grounds, but there is a decided change in the plant life, for many forms occurring in the Lower Coal Measures do not pass to the Middle Coal Measures.

Lower Coal Measures.

Synonyms and Local Subdivisions.

Pennsylvania XII: Seral Conglomerate, Pottsville Conglomerate, Umbral in part.

Virginia and West Virginia XII.: Quinnimont Group, Lower Coal Measures.

Ohio: Lower Coal Measures in part.

Indiana.
Illinois. } Conglomerate or Millstone Grit.

Michigan.—Parma Conglomerate.

Alabama.
Mississippi.
Tennessee.
Missouri. } Coal Measures in part.

Nova Scotia. New Brunswick. Newfoundland.	Millstone Grit Formation.

This important division has been spoken of as the Conglomerate or as Millstone Grit, the great sandstone floor on which the Coal Measures rest; but the division is too important, economically and stratigraphically, to be buried under any such misnomer as Conglomerate, Seral or otherwise. Nor should its coal-beds be spoken of as Interconglomerate, for the including sandstones are often far from being conglomerate.

The upper limit is determined without difficulty throughout the Appalachian and Mississippi regions. In much of the former, however, the lower limit is somewhat indefinite, and is in the shales, referred by most authors to the Lower Carbonic. No such difficulty exists in northern Pennsylvania and Ohio, where the upper plate is the Homewood Sandstone and the bottom plate is the Sharon Conglomerate. In a general way, this structure can be traced on both sides of the Appalachian area into Tennessee, where the lower strata disappear and the Lower Carbonic limestones are brought up to the coal beds. A similar condition exists in the Mississippi river regions.

THE LOWER CARBONIC.

There is seldom any difficulty within the interior basin or the Appalachian area in determining the upper limits of the Lower Carbonic, but some uncertainty still prevails at many localities respecting the lower limit, that between the Carbonic and the Devonic. The difficulty, however, is lessening and the debatable zone is becoming narrower.

Throughout the Appalachian region, the Lower Carbonic is double, the division being well defined on both physical and paleontological grounds. The correlations of these and the subdivisions within the Mississippi valley have been determined but not in full detail. The following list shows the synonyms.

GREENBRIER.

Synonyms and Local Subdivisions.

Pennsylvania XI., Umbral, most of; Mauch Chunk, most of; Shenango Shale (?)

Ohio.	Maxville Limestone. Logan Series.	Waverly Group in part.

Virginia XI.—Greenbrier Group.

Tennessee. Alabama.	—	Mountain Limestone. Siliceous Group.

Indiana.—Mountain Limestone.

Michigan. Illinois. Iowa. Missouri.	—	Chester Group. St. Louis Group. Keokuk Group.
Nova Scotia. New Brunswick. Newfoundland.		Windsor Series.

POCONO.

Synonyms and Local Subdivisions.

Pennsylvania X., Vespertine, Pocono.	Shenango Group. Meadville Group. Oil Creek Group in part.

Virginia X.—New River Series.

Ohio: Waverly Group in part.	Cuyahoga Shale. Berea Shale and Grit. Bedford Shale. Cleveland Shale.
Tennessee. Alabama.	Absent or represented by the lowest beds of the Siliceous Group.

Indiana.—Knobstone Group in part.

Illinois. Iowa.	Burlington Group. Kinderhook Group.
Michigan.	Michigan Salt Group. Marshall Group.

New York.—Upper part of the Catskill Gray Sandstones.
Nova Scotia.—Horton Series.
Eastern Quebec.—Bonaventure Series.

No geographical term can be found which will designate the divisions properly, for which reason it might be well to retain the meaningless terms Umbral and Vespertine, applied to them many years ago by Professor Rogers; as, however, most geologists prefer geographical names, *Greenbrier* and *Pocono* will have to be accepted as most nearly meeting the requirements. These are admirable divisions for the Appalachian, and their subdivisions in the Interior Basin can be made out without any difficulty.

The contrast between the Appalachian area and the Interior Basin is very marked in rocks of the Lower Carbonic. The Greenbrier beds are persistent throughout the former area. Within most of Pennsylvania and Ohio, and along the southeast border of the area, the deposit is of shale and sandstone; while in West

Virginia, Kentucky and Tennessee, with most of Virginia, it contains a great mass of limestone. Its subdivisions beyond the Cincinnati arch are represented chiefly by limestone, a condition similar to that observed in the Eastern Border region of Nova Scotia and New Brunswick.

The Pocono is persistent within the Appalachian area as far southward as the Tennessee border, and everywhere is a deposit of shale and sandstone carrying beds of coal. This is the character of its deposits in the Eastern Border region. Within the Interior Basin the upper part is calcareous, while the lower portion is shale or sandstone, and carbonaceous matter is present in small quantity.

The relations of the lowest parts of the Marshall and Waverly are still somewhat uncertain, there appearing to be some reason for drawing a line at the Berea in Ohio, which would throw the lower beds of Ohio and the Oil Creek group in Pennsylvania into the Devonic. But the plant-remains of the Berea are more nearly related to Carbonic than to Devonic.

THE REGION BEYOND THE INTERIOR BASIN.

That the conditions in the Rocky Mountains and beyond, are different from those in the regions east from those mountains, has been mentioned already. Material for close comparison of the Carbonic of the Plateau Region with that of the Rocky Mountains and that of the Interior Basin is accumulating rapidly; but it is not yet sufficient, so that nothing beyond a merely tentative statement can be given here.

Within the Park Province of the Rocky Mountains the Upper Carbonic alone has been identified satisfactorily, the fossils being those which characterize the Coal Measures, or, at most, such as are common to both Upper and Lower Carbonic. The rocks are mostly sandstones, but limestones occur almost midway in the column and at the base. Limestone increases southward, so that in New Mexico two divisions are distinct, the lower containing much and the upper containing little limestone. Some of the lower limestones are crowded with Coal-Measures forms, which are present throughout the column, though associated near the top with an occasional type allied to Permian. The condition, in this respect, is very like that in the Appalachian region and

the Mississippi Basin. The western limit of the Lower Carbonic must be concealed by a long overlap.

Within the Plateau Province, the area drained by the Colorado river and deeply trenched by that stream and its tributaries, the Carbonic column has been divided into

Upper Aubrey.
Lower Aubrey.
Red Wall.
Lodore.

The first two consist of sandstones with some limestone, but limestone predominates in the third, while the fourth is made up of sandstone and shale. The Upper Aubrey has been subdivided into

Bellerophon Limestone.
Yampa Sandstone.

No fossils have been described from the Lodore, but the others yield abundant examples of Coal-Measures forms, many of these being identical with species occurring in the Mississippi Basin.

In the region known as the Basin Ranges, including parts of Utah, Nevada and Arizona, Lower Carbonic forms occur at many places, but are usually associated with Upper Carbonic forms. A distinctive Lower Carbonic fauna has been recognized at a few limited localities in Utah, Nevada, Idaho and Montana; but these localities are exceedingly circumscribed.

The paleontologists agree in the statement that, except at the localities mentioned, the Carbonic rocks of the far Western mountain and plateau region exhibit a commingling of the invertebrate types which characterize the different divisions of the Carbonic as they are recognized in the Mississippi Valley.

Within California the Carboniferous rocks are mostly shales, holding lenticular masses of limestone. The fossils thus far obtained hardly justify an attempt at detailed comparison with other areas.

The subjoined table is offered to represent the grouping for the Appalachian region and the Mississippi Valley:

TABLE.

Upper Carbonic.

1. Upper Coal Measures.	Permo-carbonic. Monongahela.
2. Middle Coal Measures.	Pittsburgh. Allegheny.
3. Lower Coal Measures.	Quinnimont.

Lower Carbonic.

1. Greenbrier.	Chester. St. Louis. Keokuk.
2. Pocono.	Burlington. Kinderhook.

Report of the Sub-Committee on Mesozoic.

GEORGE H. COOK,

REPORTER.

BEGINNING with the lowest, there are,—

1. The TRIASSIC. On the Atlantic slope this is represented by the red sandstones of Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Virginia, and North Carolina. It is recognized as being above the Paleozoic Group and below the Cretacic System, by its relative position in regard to these rocks on either side. By the few fossils of animal forms, it is recognized as occupying the same stage as the Keuper of Europe, though its fossil plants bear some affinity to the Jurassic of Europe. The rock material of the system is largely granitic, but varies from a very coarse conglomerate through sandstone to a fine and soft shale. It generally contains very little calcareous matter, though there is a heavy bed of calcareous conglomerate on the northwest border of the formation in New Jersey and further southwest. It is even bedded, and its materials have been derived from the older rocks bordering it on either side, and these have given character to the rock formation of the Trias near them. Attempts have been made to subdivide the System, but the different attempts do not agree, and there is need of much more study upon them. The System is remarkable for the abundance of eruptive rocks which are found in it. The thickness of the whole is variously estimated at from 1500 feet to 15,000 or more. The measurements are unsatisfactory on account of faults in the rock. The rocks mainly dip in one direction and are but little curved or folded.

There have been nearly a hundred persons who have written

upon the subject, and the papers published amount to more than twice that number. The difficulties of the subject are caused by the easy disintegration of the rock and consequent covering of it with earth almost everywhere—by the unusual uniformity of the rock in color and composition, which renders difficult the tracing of faults or other disturbances, and by the scarcity of marine

	European (Dana.)	New Jersey.	Virginia.	North Carolina.	Rocky Mt. Region.
	Lower Lias	Jurassic?	Jurassic?		
TRIASSIC	Keuper			Upper Red Sandstone	
	Muschel-kalk		Coal Bearing	Coal Bearing	
	Bunter-Sandstein	Arkose		Lower Red Sandstone	
		(Archean)	(Archean)	(Archean)	
	(Permian)				

invertebrate fossils. The relative time and mode of occurrence of the eruptive rocks are also among the subjects of discussion, and information is still needed upon all these points before satisfactory conclusions can be drawn.

In the series no Jurassic rocks can be clearly separated from the Triassic, and no line defining the upper limit of the latter has yet been drawn.

The Trias and Jurassic are extensively represented west of the Mississippi. There is a general resemblance of these to the

Eastern Trias, but the systems have been most studied in their paleontological relations, which are given in the statement by Prof. Cope.

2. The CRETACIC. This system is well represented in the United States. It is well developed in New Jersey, where its study by naturalists from Philadelphia and New York was first begun. It is there represented by the series of Raritan Clays and their included beds of sand below, which are of estuary origin, and the series of greensands and limestones above. It is also well represented in the Atlantic States farther south, and in the Gulf States by series closely resembling these. In the States west of the Mississippi it has enormous development, and though the material representing the stages varies much from that of the eastern ones, the abundance of fossils, both animal and vegetable, is such that their correlation with those of the East is well shown. The tabular statement below shows the position of the series in this System as fully and closely as yet determined, and the Rocky Mountain section shows the development of the Cretacic near the northern boundary.

In this tabular form of showing the members of the Cretacic Series, it will be understood that their correlation is not absolutely assured. Dr. Newberry's studies lead him to the conclusion that the Raritan clays are as recent as the Upper Green-sand of Europe and perhaps nearer the Lower Chalk. Prof. Whitfield's work in the Paleontology of the Cretacic leads him to think the Lower Green-sand marl bed of New Jersey is of the same age with the Ripley group of the southwest States,—some others place the Ripley group very high in the Upper Cretacic; and the correlation of some of the lower members of the series is very far from being settled. The Alabama-Mississippi statement is from the surveys of Smith and Johnson, as given in Bulletin 43 of the U. S. Geol. Survey; that of Texas, from R. T. Hill's paper in the *Am. Jour. of Science*, vol. xxxiv. (3d ser.), p. 287. The Potomac is inserted from the paper of W. J. McGee, in *Am. Jour. Sci.*, vol. xxxv. (3d ser.), p. 120. The North American is from the Reports of Meek, Hayden, King, Cope, White, and others.

That of the Rocky Mountains is from the Report of G. M. Dawson, in the Geol. Report of Canada for 1885, B, page 166.

Cretacic.

European (Dana.)		New Jersey.		Alabama and Mississippi.	Texas.		Interior North American.	Canadian Rocky Mountain.
Upper Cretacic	N. J. Green-sands.	Upper Green-sand Marl Bed	37 ft.	Ripley formation. Sands and Little Clay 250–275 ft.	Ripley	1000 to 1500 ft.	Foxhills 30–1500–3500 ft.	Foxhill and Pierre ? ft.
Upper or White Chalk		Yellow Sand	43 ft.					
		Middle Green-sand Marl Bed	45 ft.		Rotten Limestone			
		Red Sand	100 ft.	Rotten Limestone Argillaceous Limestone Calcareous Clays 1000 ft.				
Lower or Gray Chalk		Lower Green-sand Marl Bed	30 ft.		Tombigbee Sands		Pierre 250–300 ft.	
		Clay Marls	277 ft.					Bellyriver Series ? ft.
Middle Cretacic (Upper Green-sand)				Eutaw Formation Calcareous Sands and Green-sands and Clays 300 ft.	Eagle Ford Shales		Niobrara 100–200 ft.	Niobrara and Benton 1400 ft.
					Lower Cross Timbers		Benton 200–450 ft.	Volcanic Rocks 2200 ft.
Lower Cretacic (Lower Green-sand)	Raritan Clays.	Sand Clay and Lignite	50 ft.	Tuscaloosa Formation Clays and Sands 1000 ft.	Comanche Series. Washita Division Chalky Limestone	2000 to 5000 ft.	Dakota 300–400 ft.	Dakota and Upper Kootanie to Coal Series 2750 ft.
		Clay and Sand	40 ft.					
		Stoneware Clay Bed	30 ft.					
		Sand and Clay	50 ft.		Fredericksburg Division Cuprina Limestone			
		South Amboy Fire Clay Bed	20 ft.					
		Kaolin	13 ft.					
		Feldspar	5 ft.					
		Micaceous Sand Bed	20 ft.		Basal Sands		Comanche ? ft.	Lower Part of Kootanie Series 7000 ft.
		Laminated Clay and Sand	30 ft.	Potomac				
		Pipe Clay	15 ft.					
		Woodbridge Fire Clay Bed	20 ft.					
		Fire Sand Bed	15 ft.					
		Raritan Fire Clay Bed	15 ft.					
		Raritan Potters' Clay Bed	24 ft.					
		Archean						

[NOTE.—If the question in regard to names is not already settled, I should earnestly advocate the transposition of the terms *Group* and *Series*, so as to have Series used for the names of the first order, and Group for those of the third order. This use of the words is nearer in accordance with the present usage of English-speaking geologists.]

MESOZOIC REALM.*

BY PROF. COPE.

This system is distinguished from the Paleozoic in North America, as to the Vertebrata, as follows:

Presence of Reptilia Dinosauria, Ichthyopterygia, Sauropterygia? Pterosauria, Testudinata, and Lacertilia; presence of Mammalia. Absence of Tunicata Antiarcha, Agnatha Arrhina, and Diplorhina, of Pisces Placoganoidei, of Batrachia Ganocephala? Rhachitomi and Embolomeri, and of Reptilia Theromorpha.

From the Cenozoic system the Mesozoic differs in the presence of Reptilia Dinosauria, Sauropterygia, Ichthyopterygia; of Mammalia Marsupialia Multituberculata; and in the absence of Pisces Actinopteri, Nematognathi, and Plectospondyli; of Aves Insessasores, and Mammalia Diplarthra and Rodentia.

The primary systems of the Mesozoic are four, viz.:

Postcretacic,
Cretacic,
Jurassic,
Triassic.

TRIASSIC SYSTEM.

The vertebrate fauna is characterized by the presence of Reptilia Belodontidæ and Aëtosauridæ, and of Mammalia Dromatheriidæ; also by the absence of Dinosauria Opisthocœla, Orthopoda, Parasuchia, and Eusuchia; of Batrachia Anuria and Urodela; of Saurodont and of Physoclystrous fishes.

The division of the Trias into Muschelkalk and Keuper, so well marked in Europe, is not possible in North America, our

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* Prof. Cope objects to the adoption of the word "group," as proposed by the Congress of Berlin, for the division of geological formations of the first rank, and proposes to substitute the word "realm" therefor; *e.g.*, the Archean, Paleozoic, Mesozoic, and Cenozoic Realms.—*American Naturalist*, 1887, p. 445.

beds presenting the faunal characters of the Keuper or upper Trias of that continent. They, however, present two divisions which are lithologically distinct in Nevada, to which Mr. King has given the names Koipato to the lower and Star Peak to the upper. The latter is of marine origin, while the Trias of the Rocky Mountains and of the Atlantic slope is lacustrine. The Rocky Mountain Trias is exposed upturned along both the eastern and western slopes of north and south ranges, and the north and south slopes of east and west ranges. In Nevada it forms the mass of the Havalla, Pah Ute, and West Humboldt ranges. Its thickness is, according to King:

	Feet.
Colorado, east flank of mountains, ...	300 to 1200
Nevada, Koipato bed, ...	4000 to 6000
Nevada, Star Peak bed, ...	10,000

Triassic beds probably also occur in the Indian Territory.*

JURASSIC SYSTEM.

The vertebrate fauna is characterized as follows:

Present: Reptilia Dinosauria Opisthocœla, Orthopoda, Mesosuchia; Testudinata Clidosterna; Ichthyopterygia Sauranodontidæ; Batrachia Anura; Mammalia ? Bunotheria. Absent: Pisces Actinochiri, Saurodontidæ; Percomorphi; Dinosauria Belodontidæ; Reptilia Choristodera; Aves Odontornithes; Mammalia Placentialia Ungulata, Creodonta, and Tillodonta.

The Jurassic bed constantly overlies the Triassic along the flanks of all the Rocky Mountain ranges, consisting of clays, shales, marls, and cherty limestones. In Colorado it has, according to King, a thickness of seventy-five to two hundred and fifty feet. It grows thicker westward, reaching seven hundred feet on the west flanks of the Sierra Madre, in New Mexico, and, according to King, consists in Nevada of

	Feet.
Slates, ...	4000
Limestone, ...	1500 to 2000

The forms of vertebrates found apparently together at this horizon are represented in Europe by genera of different sub-

* Triassic formations have not yet been detected in Texas, those recently referred by Mr. Hill of the United States Geological Survey to that age being the Permian beds of the Red River (see *Amer. Jour. Sci.*, 1887, p. 302).

divisions of the Jurassic. Hence it has not been possible to refer the Rocky Mountain beds to any of the latter, and Marsh has therefore designated them as the *Atlantosaurus* beds.

A series of deposits lies between the Triassic and Cretaceous formations in the middle Atlantic States, which have been supposed from the paleobotany to be of Jurassic age by Tyson. What division, if any, of the European series they represent has not yet been ascertained, but they are regarded by Mr. McGee as belonging at the summit of the system. He names them the Potomac formation in an unpublished memoir.

CRETACIC SYSTEM.

Characteristics.—Presence of Saurodont and Actinochirous fishes; of Reptilia Eusuchia, Testudinata Protostegidæ Propleuridæ, and Adocidæ; of Aves Odontornithes. Absence of Pisces Ginglymodi and Halecomorphi; of Reptilia Choristdera, Dinosauria Opisthocœla.

This formation has great extent and thickness in North America, and it displays a number of divisions, which differ both lithologically and faunally. These are the

Foxhills,
Pierre,
Niobrara,
Benton,
Dakota,
Comanche.

The COMANCHE has been recently named and described by Hill. It consists principally of limestones of varying character which contain numerous marine invertebrata, which have been determined by White to represent a horizon of the Cretacic lower than the Dakota, and corresponding with some member of the Lower Cretacic of Europe. No vertebrates known. The formation is seen between the east and west Cross-Timbers of Texas, and the thickness is not given.

The DAKOTA has not yet produced vertebrate remains, but abounds in plants which have, according to Lesquereux, the character of those of the Turonian or Lower Chalk of Europe, with an admixture of Miocene and recent types. Its beds consist of generally hard sandstone and conglomerate, and they occur almost everywhere along the flanks of the Rocky Moun-

tain uplifts, forming distinct hog-backs. The thickness is from three to four hundred feet.

The BENTON.—These beds consist of dark-colored clays, more or less shaly, and have a thickness of from two hundred to four hundred and fifty feet. They contain vertebrate fossils, mostly fishes in poor preservation. The only vertebrate type observed in it which gives it character is a crocodilian reptile, with flat articular vertebral faces, provisionally referred to the genus Hyposaurus. The Benton formation is widely distributed, usually present where the Dakota occurs, and lying conformably on it, and from its soft material, forming valleys.

The NIOBRARA.—Composed of harder and softer argillaceous limestones and chalky marls, varying from one hundred to two hundred feet in thickness. The Niobrara is present with the Dakota and Benton on the flanks of the Rocky Mountains, but has also a wide extent east and southeast of them, forming a large part of The Plains, and other large tracts in Texas.* It probably occurs in the valley of the Red River of the North. It is a deep-water formation, and is very rich in fossils, vertebrate and invertebrate. Characterized as follows:

Present: Pisces Isospondyli Saurodontidæ, and Actinochiri, Hemibranchi Dercetidæ; Reptilia Sauropterygia with long necks; Pythonomorpha, except Mosasaurus; Testudinata Protostegidæ; Pterosauria Pteranodontidæ; Aves Odontornithes. Absent: Reptilia Crocodilia Procœla; Pythonomorpha, Mosasaurus.

PIERRE.—Dark carbonaceous shales and clays, and dark-colored marls, which lie conformably on the Niobrara beds both on the flanks of the Rocky Mountains and on the northern parts of the Plains. Thickness (King), two hundred and fifty to three hundred feet. Represented in the East, according to Meek and Whitfield, by the lower green-sand marl of New Jersey, Delaware, etc. Invertebrate fossils very numerous; vertebrates less numerous in the interior basin, more so on the Atlantic slope. The predominant genera in the two regions are Mosasaurus and Elasmosaurus, the latter occurring also in the Niobrara. The distinctness of this horizon from the latter on grounds of vertebrate paleontology depends chiefly on the fauna of the Eastern beds. The distinctions are:

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* See page 469 *American Naturalist*, May, 1887.

Presence of Reptilia Crocodilia Procœla; Pythonomorpha Mosasaurus. Absence of Pisces Isospondyli Actinochiri; Pterosauria Pteranodontidæ; Aves Odontornithes.

It remains to be seen whether these differences will remain under future investigation.

Foxhills.—Formed of sandstones more or less argillaceous, varying in thickness from thirty feet (Cope), Montana, to fifteen hundred feet (King), Colorado, to three thousand to thirty-five hundred feet in Southwest Wyoming (King). The vertebrate fauna in the West is sparse, but in New Jersey it is very full. It is characterized in Montana by

Presence of Pisces Holocephali; Haplomi (Ischyrhiza); Reptilia Pythonomorpha and Sauropterygia with short neck (Uronautes); Crocodilia Procœla.

In New Jersey it has the same characters, with the additions:

Present: Pisces Percomorphi Berycidæ; Reptilia Testudinata Adocidæ and Pleurodira. Absent: Pisces Isospondyli Actinochiri.

Mr. King has combined the Benton, Niobrara, and Pierre into a single division, which he called the Colorado. On paleontological grounds there is as yet no more reason for uniting these without than with the Foxhills group. If the Foxhills is retained as distinct, the others should be also. However, future research may change the present aspect of the case.

Total thickness of the Cretacic of the West, about four thousand nine hundred feet.

POSTCRETACIC SYSTEM.

This name was proposed by Endlich and adopted and afterwards abandoned by White for the lacustrine formations which rest conformably on the upper beds of the Cretacic (Foxhills), whose paleontology will not permit them to be ranged with the Cenozoic system. The Vertebrata are as follows:

Presence of Pisces Ginglymodi and Halecomorphi; Reptilia Choristodera; Mammalia Marsupialia Multituberculata. Absence of Pisces Isospondyli Saurodontidæ and Actinochiri; of Reptilia Sauropterygia and Pterosauria.

There are two well-marked epochs of the Postcretacic,—the Puerco and the Laramie.

Laramie.—Present: Pisces Elasmobranchi Myledaphus;

Reptilia Dinosauria Goniopoda and Orthopoda. Absent: Mammalia Placentialia.

This formation has an immense extent on the northern plains in the United States and Canada; along the eastern flank of the Rocky Mountains, and on the western flanks of the same in New Mexico, and along the Lower Rio Grande in Texas and Tamaulipas. It consists of sandstones, marls, and lignite, whose base rests conformably on the Foxhills beds of the Cretacic, when the latter is present. Thickness:

	Feet.
East flank of Rocky Mountains, Colorado (King), .	1500
Southwestern Wyoming (King), ...	5000
Upper Missouri, Montana (Cope), ...	500
Northwestern New Mexico (Baldwin and Cope), . . .	2000

It is stated by White,* and agreed to by Ward and Newberry, that there are two epochs included under the name Laramie. This upper division, which has the greatest geographical extent, was named long ago by Hayden the Fort Union division. The other and lower or older division is the Bearriver of Hayden. The molluscan species of the two horizons are very different. The Bearriver beds are seen near Evanston, Wyoming, and in perhaps one or two other localities only.

A formation has been observed along the Belly River, in Saskatchewan, by the geological survey of the Dominion of Canada, which they call the Bellyriver. It is overlaid by the Pierre, and would be placed in the system in accordance with this position between that formation and the Niobrara below it. But the flora and the fauna, vertebrate and invertebrate, are identical, or nearly so, with that of the Laramie. The explanation of this singular state of the evidence has not yet been reached.

PUERCO.—Present: Mammalia Placentialia. Absent: Pisces Elasmobranchi; Reptilia Dinosauria Goniopoda and Orthopoda.

The fauna of this horizon is well distinguished from that of the Laramie in the absence of the numerous Dinosauria of the latter, and the presence of numerous placental mammalia in the former. On these grounds I at first referred the formation to

* I do not claim two epochs for the Laramie proper, as I believe Ward does. I show that the "Bearriver Laramie" fauna is entirely different from that of the Laramie proper; but I don't know which is the older, or if either is. No plants have been found in the Bearriver Laramie. C. A. W.

the Cenozoic series, but further reflection induced me to place it as now arranged. The reason is as follows: Although Placental Mammalia are not now known otherwise from Mesozoic beds, the other forms of the Puerco are especially Mesozoic in character. Such are the Choristodere Reptilia and the Multituberculate Marsupialia, neither of which occur above, while both occur below the Puerco, the Multituberculata down to the Trias inclusive. Then the Placentialia are entirely peculiar in the absence of the Diplarthra and of the Rodentia, orders always found in the Cenozoic beds. Then the characters of the Condylarthra and Amblypoda and many of the Creodonta, which represent Tertiary types, are so peculiar that we are led to suspect that when the Cretacic Mammalia are fully known they cannot differ very widely from those of the Puerco.

But one area of this formation is definitely known; this is in Northwestern New Mexico and Southwestern Colorado. It consists of sandstones and soapy marls, and has a thickness of eight hundred and fifty feet. It is immediately overlaid by the Wasatch Eocene, and rests on the Laramie.

Total thickness of the Mesozoic system (greatest):

	Feet.
Triassic,	16,000
Jurassic,	6,000
Cretacic,	4,900
Postcretacic,	5,850
	32,750

NOTE ON THE MESOZOIC SYSTEMS.

The Report on the Geology of the Uinta mountains having been published in 1876, according to the date on the title-page, while the vols. i. and ii. of King's *Report on the Geology of the Fortieth Parallel* were not published until 1878 and 1877 respectively, it becomes necessary to examine whether any of the names used by the latter author are antedated by any of those of Powell. The Mesozoic sands below the Cretacic given by Powell are the following, in descending order. They are all referred (p. 41) to the Jura-Trias system.

Flaming Gorge,	1200 feet
White Cliff,	1100 "
Vermilion Cliff,	1100 "
Shinarump,	1800 "

I am informed by Major Powell that the Shinarump series is that which I have referred, on account of its vertebrate fauna, to the Permian. It is therefore to be excluded from the Mesozoic realm. Of the three remaining series the Vermilion Cliff is, to judge from the description, that which I referred to the upper or Keuper Trias in 1877 (Report Expl. Sur. W. of 100th Meridian, G. M. Wheeler, vol. iv.), while the two others are referable to the Jurassic. It is not unlikely that they are identical with the two divisions into which King divides the Jurassic system of Nevada, and if so, the names of Powell take precedence of those of King. Until this identity is determined by direct tracing, or by paleontological comparison, their relations will remain uncertain.

E. D. COPE.

Report of the Sub-Committee on Cenozoic (Marine).

EUGENE A. SMITH,

REPORTER.

NOTWITHSTANDING the fact that marine Tertiary deposits have long been known to form an almost continuous border along the Atlantic coast from Massachusetts to Florida, and along the Gulf coast from Florida to Texas, our knowledge of the Tertiary of America, in the language of Professor Dall, is still so fragmentary and imperfect as to render a synchronic subdivision of the post-Cretaceous strata impossible for the present.

Many papers descriptive of these Tertiary formations and especially of their fossil contents have been published from time to time, and fairly complete descriptions of the deposits in particular States have been given to the world, as by Tuomey in South Carolina, Hilgard in Mississippi, by Tuomey, Smith and others in Alabama. While all these papers contain partial correlations and comparisons, in Professor Heilprin's U. S. Tertiary Geology, we have the only attempt thus far published at a systematic review and analysis of the formation taken as a whole.

In Alabama the lower beds of the Tertiary are more extensively developed than elsewhere in the United States, and they have been recently carefully studied, so that the order of succession, lithological characters, relative thickness, and the fossil contents of the various strata which make up this formation in Alabama along the Alabama and Tombigbee rivers where best exposed, are now known with a very considerable degree of accuracy. For these reasons it is thought that a short account of the

stratigraphy of the Tertiary beds of Alabama will perhaps form the best introduction to the subject.

EOCENE.

The Tertiary beds of Alabama thus far known have been considered as Eocene, and their subdivisions are as follows:

Eocene,	Upper,	White Limestone,	350 feet.
	Middle,	Claiborne,	150 "
		Buhrstone,	300 "
	Lower,	Lignitic,	900 to 1000 "

Along the Tombigbee and Alabama rivers we find directly overlying the sandy and calcareous beds that form the uppermost of the undoubtedly Cretaceous deposits, known as Ripley, first, a crystalline limestone, then an impure argillaceous limestone, both bearing a decidedly Cretaceous aspect, but, according to the determinations of Mr. L. C. Johnson, containing fossils which are undoubtedly Tertiary. These beds increase very greatly in thickness towards the eastern part of the State.

Above these limestones are seen about 100 feet of black clays passing upwards into a great mass, 800 feet or more, of grayish cross-bedded sands interstratified with thin sheets of gray clay and occasional beds of lignite, and, at seven or eight horizons, holding beds containing marine fossils. The black clays which lie at the base of this division form the substratum of what Hilgard has called "the Flatwoods," and they correspond in the main with Safford's Porter's Creek group in Tennessee.

The rest of this series above the black clays has been called, by Dr. E. W. Hilgard, the Lignitic—(Professor Heilprin has suggested the name Eolignitic),—and it has a thickness along the two rivers of 800 to 900 feet. The fossils of the seven marine beds above alluded to have been recently studied by Mr. T. H. Aldrich of the Alabama Geological Survey.

Westward in Mississippi, according to the investigations of Mr. L. C. Johnson, the lower beds appear to thin out and their place to be taken by a lignitic phase of the Siliceous Claiborne of Hilgard. In eastern Alabama and Georgia, also, these lower lignitic beds appear to thin out, while the interstratified marine shell beds become more prominent.

While holding many fossils identical with those of the next

overlying subdivision, the Lignitic has a rather characteristic invertebrate fauna, many new forms of which have been described by Mr. Aldrich in Bulletin No. 1 of the Alabama Geological Survey. This, the Lignitic, constitutes our *Lower Eocene* division.

Overlying the Lignitic and constituting our *Middle Eocene* are some 450 to 500 feet of strata which we for certain reasons subdivide into two parts, the lower of which, 300 feet or more in thickness, has retained Professor Tuomey's name "Buhrstone," and the upper, 150 feet thick, the name of "Claiborne" from its best known and most characteristic exposure.*

While we have not been able to point out any very well marked difference in the specific characters of the faunas of these two divisions, yet they differ widely in the relative abundance of their fossils as well as in their lithological characters. The Buhrstone is made up of claystones, aluminous sandstones, and quartzites chiefly, with an exceedingly meagre fauna represented for the most part by casts or moulds, while the overlying Claiborne beds, consisting of sands and clays, hold a vast number and great variety of well-preserved shells. The *Claiborne fossiliferous sand*, which is the name applied to a bed about seventeen feet in thickness, near the top of this division, is a yellowish ferruginous sand (originally a greensand), literally packed with the most perfectly preserved shells. It is this stratum which has furnished to the world most of the "Claiborne" fossils. It is doubtful if this bed is found outside of Alabama, or even at any considerable distance from the type locality, unless the main fossil-bearing bed at Jackson, Mississippi, be a representative of it.†

The greater part of the Claiborne bed consists of calcareous

* Dr. Hilgard includes both the Buhrstone and the Claiborne in his Claiborne division, characterizing them as Siliceous Claiborne and Calcareous Claiborne, respectively.

† The collections of Mr. Aldrich show that over fifty per cent. of the Jackson shells are common also to the Claiborne fossiliferous sand; but, on the other hand, Dr. Hilgard has found nearly every Jackson shell, at some point or other, associated with the Zeuglodon matrix, which has usually been classed with the White Limestone. The occurrence of Aturea, a Claiborne form with the remains of Zeuglodon, will probably cause us to include the Zeuglodon-bearing beds with the Claiborne, which would increase the thickness of the Claiborne to 210 feet and diminish that of the White Limestone correspondingly by about 60 feet.

sands, with much glauconite, and characterized by the prevalence of shells of *Ostrea Sellæformis.* This is by far the most characteristic and persistent of the beds of the Claiborne formation. It extends certainly from Caldwell county in Texas, through Louisiana, Mississippi, Alabama, Georgia, and thence on to Maryland. In places this part of the Claiborne division becomes highly ferruginous from preponderance of glauconite, giving rise to "red land" spots, and even to beds of iron ore, as near Duck Hill in Mississippi. According to Dr. Hilgard this ferruginous feature increases to the westward, until in Louisiana it makes a prominent one of the country and becomes geologically as well as practically an important mark.

Above the Claiborne and forming our *Upper Eocene,* is the division which we have called the White Limestone, in places 350 feet in thickness, though generally only about 200 feet.

The White Limestone is subdivided into a lower part, 60 feet thick, consisting of impure argillaceous limestones, holding in many places, especially westward near the State line of Alabama and over the line in Mississippi, beds of gypsum and gypseous clays; a middle part, 200 feet thick, of rather pure white limestone containing, as a characteristic fossil, *Orbitoides Mantelli;* and an upper part, 150 feet thick, of white limestone containing large masses of silicified corals and a great number of plates and spines of echinoderms. In Mississippi, the uppermost beds of Marine Tertiary consist of alternating beds of Orbitoidal limestone and clays, some 100 feet or more thick, with about 60 feet of a lignitic clay at top.

The lower sixty feet of the White Limestone are included in what Hilgard has called his Jackson formation. In this, and characteristic of the formation, are the remains of *Zeuglodon Cetoides.**

The main mass of the White Limestone, its middle member, is the orbitoidal rock which, there is no reason to doubt, belongs to the Vicksburg division as defined in the Mississippi Surveys.

The uppermost 150 feet of the White Limestone we have seen in one locality only; but there resting apparently conformably upon the orbitoidal rock.

While the average Gulf-ward slope of the Tertiary formation

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* We have already given some reasons for placing this division along with the Claiborne.

in Alabama may be placed at 30 feet to the mile, there are many interruptions to the uniformity of this slope, and we have recently traced out, in part at least, the limits of two anticlinal folds and one fault involving at least 200 feet vertical displacement; and the wide expanse of territory over which, in southern Alabama and Florida, the White Limestone remains at or near the surface, shows that the Tertiary strata in those parts, probably because of these folds, have very little or no Gulf-ward slope, and, in some places, even a dip away from the Gulf.

All the strata above described have been classified as Eocene, without a dissenting voice, except the White Limestone, parts of which have been considered as of Oligocene age by Conrad, Heilprin, and others; but recently-made and extensive collections lead us to consider the White Limestone also as Eocene. On this point the following quotations are made. Mr. T. H. Aldrich, who has recently devoted much time to the collection and study of the fossils of the Alabama Tertiary, says: "I cannot find any good reason for calling the Vicksburg, or White Limestone, Oligocene; the presence of *Venericardia planicosta* in it near Claiborne is enough to put it into the Eocene, but outside of that the fossils are not similar to the Oligocene of Europe in any way whatever. Oligocene of Europe is much more recent in its forms, more like Miocene in this country."

Dr. E. W. Hilgard writes: "As to 'Oligocene,' I can see no possible use in such a subdivision in the S. W. Tertiary; I hold that the Vicksburg and Jackson are so closely interconnected, and also—as your Alabama exposures show—so closely related with the Claiborne, that if the latter is called Eocene the other two must be."

L. C. Johnson says: "But the Jackson, Vicksburg, and Red Bluff having some differences, have yet so much in common, that I put them in one division—the White Limestone formation—and, unless my recollection is at fault, we agreed upon this before, and also that it is truly Eocene, as Tuomey and Hilgard were of opinion."

At this point, though probably out of the proper order, we had perhaps best speak of a fresh-water formation of somewhat wide distribution in Mississippi, viz., the Grand Gulf formation of Hilgard, made up of sandstones, sands and clays, in which organic remains are extremely rare; the few fossils which have

been found in these beds, Unios, etc., are fresh-water forms, and while pointing to the probability of Miocene or even later age, are still by no means conclusive.

Concerning this formation Dr. Hilgard writes as follows:

"As to the Grand Gulf series, the absence of any definite dip comparable to that of the Vicksburg beds, indicates an unconformity which I cannot exactly reconcile with the almost indefinite lithological and stratigraphical transitions I have traced on the hillsides, falling off to northward into the Vicksburg prairies. I hold, as I have said in my article on the subject, that something has happened at the end of the Vicksburg era that completely changed the conditions of deposition, and may have covered a long geological time; perhaps both Miocene and Pliocene, if Tuomey's S. C. Pliocene is relegated to the Post-Pliocene, as somebody has threatened to do.

"You know that in the deep borings at New Orleans nothing that would indicate a Tertiary deposit was found. I can't help thinking that when the stratigraphy of the Vicksburg beds in Alabama and Florida has been studied, they will be found to dip much less than in Mississippi,* giving color to my conjecture that their dip at Jackson and Vicksburg is partly due to deposition on a slope; if so, the apparent nonconformity between the Vicksburg and Grand Gulf may vanish. Loughridge's Barrens sandstone in Georgia seems to lie in precisely the same horizon as the Grand Gulf, and on the N.E. seems to connect with the South Carolina Miocene, equivalent to that, the Patapsco in Maryland. Perhaps the key to the situation may be found in Florida, in a section across the peninsula."

And upon another occasion as follows:

"I have no new light to give on the subject of the Grand Gulf beds. As a local [Gulf] feature, I consider them incapable of construction by themselves, with reference to the other Post-Eocene tertiaries. Besides, the mouth of the great Mississippi estuary is a bad place at which to study marine phenomena. Texas and Yucatan formations will doubtless be found to settle the question for good. I hardly think that the non-conformity

* The explanation of the difficulties suggested by Dr. Hilgard may probably be found in the existence of undulations and faults in the Tertiary formation recently traced out in Alabama, and described in Bulletin No. 43 of the U. S. Geological Survey.

in the latitude of Jackson can be settled by the existence of a fault or fold, although the latter is a welcome suggestion with respect to the unaccountable irregularity between Canton and Byram. The absence of rise in any wells bored in the Grand Gulf beds anywhere, while rise occurs in all the borings in the marine beds, seems to indicate some sudden break after all. I have nowhere been able to find a sufficiently long exposure in the direction of the dip to trace unconformity on the contact between Grand Gulf sandstone and the lignito-gypseous beds overlying the orbitoides rock."

By way of comparison and as a summary of what we have been able to determine as regards the distribution of the Eocene strata in the Atlantic and Gulf regions of the United States, the following is submitted:

Lignitic.—The beds of this division appear to have their maximum development in Alabama in the vicinity of the Alabama and Tombigbee rivers, where they consist of sands and clays usually strongly glauconitic, holding beds of lignite, and interstratified with several distinctively marine beds with characteristic fossils. Towards the east the marine beds become more prominent almost to the exclusion of the lignitic feature, but beyond Georgia, or even for any considerable distance into Georgia, this division has not yet been certainly identified, although a part of the Maryland Tertiary beds appear to belong here.

Towards the west and northwest, the lignitic feature is retained, but the beds which can certainly be identified as belonging to this division appear to be thinner in Mississippi and Tennessee than in the type localities. The difficulty in identification is chiefly due to the comparatively insignificant development of the marine beds, and to the fact that the other overlying divisions of the Eocene in these States assume a lignitic character. Thus both the Claiborne and Vicksburg in Mississippi are much more decidedly lignitic than in Alabama. Beyond the Mississippi we are still less able to distinguish between the true Lignitic and the lignitic phases of the other divisions.

Buhrstone.—This division has been identified in South Carolina, Alabama, and Mississippi, with practically the same features in each State. Beyond the Mississippi we have no certain notes of its occurrence.

Claiborne.—The lower part of this division which is characterized by the prevalence of shells of *Ostrea Sellæformis*, is by far the most widely distributed and persistent as to quality of all the Tertiary formations. It has been identified in all the States of this region from Texas to Maryland. A notable feature in some localities is the highly ferruginous character of some of its rocks, connected in all probability with the great abundance of glauconite.

White Limestone, or Vicksburg.—This is another widely distributed and persistent formation, which if made to include also the Jackson beds, may be seen from Texas to South Carolina. In Florida the White Limestone underlies a very considerable part of the peninsula.*

In the following tabular presentation of the Eocene as it occurs in Alabama, the Jackson has been placed with the White Limestone, with which it is always very closely related, both in lithological characters and in surface distribution :

CHARACTER AND SUBDIVISIONS OF THE EOCENE OF ALABAMA.

			Thickness, feet	
Eocene.	Upper 350 feet, White Limestone	Coral Limestone, . . .	150	350
		Orbitoidal Limestone, .	140	
		Jacksonian, ...	60	
	Middle 450 feet, Claiborne of E. W. Hilgard	Claiborne, ...	150	450
		Buhrstone, ...	300	
	Lower, 930–950 feet, Lignitic	Hatchetigbee, ...	175	935
		Wood's Bluff, ...	85	
		Bell's Landing, ...	200	
		Nanafalia, ...	200	
		Naheola, ...	150	
		Black Bluff, ...	100	
		Midway, ...	25	

OLIGOCENE.

If the name Oligocene is to be retained for any of the strata of the Gulf series, it will probably be applied to certain rocks described by L. C. Johnson as directly overlying the Eocene white limestone which forms the substratum of a considerable part of the peninsula. In this connection, Mr. Johnson says: "We have no Oligocene unless in the nummulitic rocks of Florida, seen best in the Gulf Hammock regions of Hernando, Levy, and Wakulla. . . . . . In a few spots, these (the Vicksburg rocks) are covered over by a variation of which I am not certain. The

* Am. Journal Science, vol. xxi., April, 1881.

principal characteristic of this upper layer is the multiplication of the nummulites, and the gradual disappearance of the orbitoides. In rocks about Levyville these are wholly wanting. There are also some peculiar radiata."

MIOCENE.

As regards the strata of this age along the Atlantic coast, we have nothing to add to what has been set forth by Prof. Heilprin,* who recognizes a practically continuous belt of post-Eocene Tertiary beds extending from New Jersey to South Carolina, and probably on into Florida. While differences have been noted in the shells of these beds in the different States, Prof. Heilprin refers them to the Miocene.

In Florida, rocks of this age have been known for some time, and from different localities, chiefly until recently, from the eastern side of the peninsula. More recently they have been seen by Johnson, Heilprin, and Dall, also in the western and southern parts of the peninsula; and Professors Heilprin and Dall have lately shown that much of what was formerly considered as Eocene and Oligocene on the western coast, near Tampa, is probably Miocene.

Mr. Johnson has also observed the materials of this age occupying depressions in the Eocene limestone, for instance near Gainesville, and some of the Miocene deposits of the southern part of the peninsula lately observed by Heilprin may also hereafter be found to rest upon Eocene rocks. It is a matter of interest to note that the greater part of the materials collected from some of the deposits of this age, especially in the central parts of the State, hold, both in the shell casts and the matrix, a high percentage of phosphoric acid, and underlie, and give origin to the fertility of, the High Hammocks. On the eastern coast this belt of Miocene rocks is probably continuous with the Miocene of Georgia, South Carolina, and other States of the Atlantic coast.

In the other Gulf States no deposits referable to the Miocene have as yet been observed, with the exception already noted, of the Grand Gulf beds of Mississippi and the States to the westward. On account of the dearth of fossils in this division and

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* U. S. Tertiary Geology.

the non-characteristic nature of those that have been discovered, the age of the Grand Gulf beds is still an open question.

LATER TERTIARY.

Concerning the later Tertiary deposits, I have at present no report to make, and the attention of the reader is invited to the note of Prof. Dall in the Appendix, in which it will be seen that we are as yet very far from having a satisfactory arrangement of the later Tertiary formations of the Atlantic coast. Concerning the Tertiary formations of the Pacific Coast I have also no report to make at this time.

In the Appendix are presented the views of a number of the Geologists of the United States, who have made the Tertiary a subject of special study, upon the classification and nomenclature of the deposits of this age.

NOTE.

PHILADELPHIA, JULY 29, 1887.

DR. EUGENE SMITH:

DEAR SIR: In response to your request for suggestions bearing upon the classification of the Tertiary deposits, I would respectfully submit the following:

The first important question touched upon by the International Congress (Rep. Am. Com., p. 61) is whether the Tertiary forms the last of the geological systems; otherwise stated, if it is followed by a Quaternary System. There is nothing, it appears to me, either stratigraphic, lithologic or paleontologic, which permits us to recognize a Quaternary System as something apart from the Tertiary. A true classification of geological time must be based almost exclusively upon faunal characters, since these alone afford us criteria applicable to the world at large. Recognizing this fact, it must be manifest, if our conceptions of the Tertiary be correct, that the Quaternary is a part of this system, since, faunally, it is much more intimately related to the Pliocene than the Pliocene to the Eocene, members of one and the same system.

Recognizing, then, the Quaternary to belong to the Tertiary series, it will be admitted that all the Post-Cretaceous deposits

constitute one comprehensive group, for which the name Kainozoic, Cenozoic, or Tertiary may be retained, and which may be considered to be in a broad way the equivalent in rank of the Mesozoic or Secondary group.

It remains now to consider in how far this Cenozoic or Tertiary Group is itself divisible, and if any of the divisions are entitled to the rank of a major position or *System*.

Geologists have very generally considered the terms "Eocene,' "Miocene," and "Pliocene" to be, from a classificatory point of view, about equivalents of Cretaceous, Jurassic, or Devonian; equal system values are given to these formations, which are then followed by a more or less anomalous placing of Post-Pliocene, Glacial, Quaternary, and Recent. A more judicious arrangement, and one more in conformity with the classification of the Paleozoic deposits, would, it appears to me, be the subdivisions of the entire Post-Cretaceous deposits into three distinct series, which may be conveniently termed, beginning with the oldest, the Paleogene (or Eogène), Metagene, and Neogene,—the *first* to include the Eocene and Oligocene of geologists; the *second*, the Miocene, and the *third*, the Pliocene, Plistocene (Glacial, Quaternary, auct.), and Recent. The relation would stand thus:

Cenozoic or Tertiary.	Neogene, . . .	Recent.
		Plistocene (Quaternary, Glacial).
		Pliocene.
	Metagene,. . .	Miocene.
	Paleogene (or Eogene), . .	Oligocene.
		Eocene.

The three divisions of the Tertiary here recommended are, it appears to me, entitled to the rank of *Systems*, since the important series which they embrace are faunally as distinct from one another as are the several series of the more ancient systems. This is certainly the case with the older Tertiary (Paleogene; Oligocene—Eocene); and hardly less so with the medial Tertiary (Metagene) as distinguished from the newer (Neogene). The upper limits of the Metagene (Miocene) can scarcely be considered to be satisfactorily determined; but there can be no doubt that the original Lyellian limitation is no longer serviceable. In my opinion the range ought to be broadened so as to very

materially increase the proportion of the living fauna—probably up to 30 or 35 per cent.*

With reference to the older formations, and to the classification of American Tertiary deposits as outlined by me in my "Contributions to the Tertiary Geology and Paleontology of the United States" (1884), and "Explorations on the West Coast of Florida, etc." (1887), the scheme here proposed would stand as follows:

CLASSIFICATION AND RELATIONS OF THE TERTIARY GROUP.

Kainozoic or Tertiary.	Neogene.	Recent. Plistocene (*Post-Pliocene, Quaternary, Glacial, etc.*). Pliocene	Deposits of the Eastern and Southern United States. Floridian (*Astian, in part*).
	Metagene.	Miocene	Carolinian (*Messinian? in part; Sarmatian, in part*). Virginian (2*d Mediterranean, in part*). Marylandian (1*st Mediterranean, in part*).
	Paleogene or Eogene.	Oligocene	Orbitoitic (*Aquitanian*).
		Eocene	Jacksonian (*Bartonian*). Claibornian (*Parisian-Calcaire grossier*). Buhrstone (*Londonian?*) Eo-Lignitic (*Thanetian?*)

Very respectfully,

ANGELO HEILPRIN.

DR. EUGENE W. HILGARD writes as follows:

"As to Tertiary *vs.* Quaternary, I am inclined to side with Heilprin, unless, indeed, we define Quaternary as being deposits holding *only* living species; and then we are confronted with the mammoth, dodo and manatee, not to speak of the dinornis and all the cave animals. It would be an artificial distinction, so far as

* As regards the Lyellian classification, your Reporter very fully concurs in the following remarks of Prof. Dall (Am. Journ. Sci., 3d Series, vol. xxxiv., p. 162): "In referring to the age of the deposits, while the old terms Miocene, Pliocene, etc., may be used for the sake of convenience, it must be clearly understood that, as at present defined, they are only of relative value and indicative at most of stratigraphical succession in a very limited sense. As determined by their invertebrate fauna, the Pliocene, for instance, of south Europe, is probably older than the strata called Pliocene in America, at all events, it is highly improbable that they represent synchronous geological epochs. The method of determining which name should be used for a particular division of the Tertiary, by taking percentages of supposed extinct species, is, on the face of it impracticable, illogical, and misleading."

faunal features go, and much less justified than would be one between Eocene-Miocene on the one hand and Pliocene-Quaternary on the other, only one does not like to consider one's self, nor yet wishes to be considered, anything so uncivilized as a Tertiary creature."

DR. J. S. NEWBERRY writes:

"In answer to your question about the retention of the subdivisions of Lyell, I would say that it seems to me that we are hardly ready to make the change that is apparently inevitable. When others have done in the States of Texas, Louisiana, Georgia, etc., in the Tertiary belt, what you have done for Alabama, or what would be better, if you could carry a line of observation over all that belt, then I think we would have the data for a change and substitution. At present Lyell's names are a convenience, but for America they must be only temporary. I do not quite agree with Prof. Heilprin as to the expediency of merging the Quaternary with the Tertiary. We all recognize the fact that the stream of life, like that of time, has flowed on uninterruptedly, and our subdivisions of geological history must be matters of convention and convenience. We find, at various places in the geological column, evidence of great physical changes; breaks which are not universal, but sufficiently marked in the structure of a continent to serve as division lines. The record of the Ice Period is one of these, and it has seemed to me to be convenient to use it as a separation between what may be considered distinct chapters in the geological history of the Northern Hemisphere. This subject will present itself under different aspects to the paleontologist and the physico-geologist, and it seems to me that we cannot make the views of either our sole guides."

PROF. R. P. WHITFIELD is of opinion, as regards the status of the Quaternary, that we need a name by which to designate the glacial and post-glacial formations, which shall be absolutely distinguishable from names applied to those preceding that great change, even if the change was not universal or only extended to the northern half of the hemisphere. Still it was perhaps as nearly universal as any great change that ever occurred and fully as great. If we recognize a Silurian System, Devonian or any

other, it is as necessary to designate the time post-glacial by some means. The change was fully as great in his opinion as that between the Cretaceous and Tertiary. He favors the retention of the name Quaternary of equal rank with Primary, Secondary, and Tertiary, to include glacial, post-glacial and recent.

MR. W. H. DALL writes:

"In response to your inquiry I can only say that the further I carry my studies of the Tertiary and recent faunæ of the Gulf and South Atlantic region, the more it is 'borne in upon me' that the divisions of the Tertiary for this part of the world, must depend upon the stratigraphy. The succession of the faunæ seems to have been even and gradual in its modifications and without sharp faunal breaks, those formerly supposed to be so seeming less and less distinct as more knowledge is obtained. There is quite a sharp distinction between the 'Pliocene' of Tuomey and Holmes, and the recent *littoral* fauna which is practically identical with their Post-Pliocene.

"The shells of the shores and the Pliocene seem well divided by discrepancies. But the off-shore dredgings of the Albatross (U. S. Fish Commission steamer) in water of less than 100 fathoms, show that, outside of the shore-fauna, there is another living fauna which is very closely related to the so-called Pliocene and nearer to it than to the living fauna of the beaches. There I find *Amusium Mortoni, Voluta mutabilis, Janira hemicyclica, Cancellaria vetusta, Venus rugatina*, and a host of others supposed to be extinct and generally first described as fossils. This introduces a wholly new question of distribution into the classification of the fossil faunæ, but of which we are yet too ignorant to go very far in generalizing." W. H. DALL.

PROF. ALEXANDER WINCHELL says:

"Assuredly, I never conceived the Lyellian divisions, Eocene, Miocene, and Pliocene, as possessing systematic value analogous to Cretaceous, Jurassic, etc., but rather as comparable with the subdivisions of Cretaceous, Devonian, Upper Silurian, etc. 'Groups' rather than 'Systems' (in the current nomenclature). But I have never conceived 'Quaternary' as coördinate in its scientific significance, with Cenozoic, Mesozoic, etc., but rather as coördinate with Eocene, Miocene and Pliocene,—and hence the

form of the term has always seemed to me objectionable and misleading. I would be willing, therefore, to dispense with the term 'Quaternary' and adopt one which in significance and form would imply a coördination with Eocene, Miocene, Pliocene. In short, I am willing to concur in the suggestion of Prof. Heilprin whose classification well expresses the facts as I understand them.

"When we turn to the so-called 'Quaternary' geology of the northern drift-covered States, we certainly find records of a Post-Pliocene period strongly and peculiarly marked.

"It is not sufficient to say that the fauna of the Quaternary presents no marked contrast with that of the Pliocene, for in districts where the Quaternary is well characterized, the physical conditions of the epoch were such as to exclude the possibility of a fauna, and we have no more basis for faunal comparisons than we have between the successive stages of the Huronian. It is still true, however, that, wherever we have discovered, in contiguous regions, the remains of faunas coeval with the epoch of glaciation, a fairly intermediate condition is found between Pliocene faunas and recent ones; hence, on the whole, I incline to think that everywhere, the events of the glacial epoch signify no more than is implied in the group-terms Eocene, Miocene, and Pliocene; and so we might well dispense with the systematic designation Quaternary."

ALEXANDER WINCHELL.

PROF. JOSEPH LE CONTE writes:

BERKELEY, CAL., December 21st, 1887.

MY DEAR SIR:

Just in regard to the Quaternary, you probably know my views. I believe the *present* ought to be a primary division and in the name of Psychozoic. I know this will not be generally received by geologists, because it is the fashion now to minimize the importance of *man*. Nevertheless, I believe it can be maintained on thoroughly scientific and still more on philosophic grounds.

1. With man one cycle of evolution, the organic, closes, and another, the psychic, commences. 2. There is going on now, under our eyes, the most rapid and sweeping change of faunas and floras that has ever taken place in the history of the earth. But because we are in the midst of it we overlook it. When civilized men shall have occupied the whole earth thickly, all other

organisms, by destruction and preservation with modifications, will be adjusted to his wants. Now if the present be raised to primary rank, then the Quaternary will become only a *transition* from the Cenozoic—like the Laramie and the Permian. And like these it will finally be classed with the lower, viz. the Cenozoic.

As to the names Eocene, Miocene, Pliocene, Plistocene, if the names can be retained I would much prefer it, for I dislike change of names unless the reasons are very strong. No doubt that Eocene is the most distinct; no doubt if Quaternary be dropped, Plistocene will unite with Pliocene.

This is all I have to say. I am not sufficiently acquainted with details to suggest anything further, my own specialty being dynamical and structural geology.

I will, however, throw out one suggestion. Perhaps you are already aware that here in California the great break is not at the end of Cretaceous but at the end of the Eocene. The Eocene merges by insensible gradations through Laramie into upper Cretaceous, so that these three seem to be one formation. For this reason Eocene was not recognized until recently—was in fact supposed to be absent altogether. This is another evidence of the greater distinctness of the Eocene.

Very truly yours,

JOSEPH LE CONTE.

Report of the Sub-Committee on the Cenozoic (Interior).

E. D. COPE,
REPORTER.

CENOZOIC REALM.*

THIS Realm is distinguished from the Cretacic, as well as from the Mesozoic formations as a whole, in North America by the following peculiarities. In Vertebrata:

By the presence of Diplarthrous Mammalia.
" " of Rodent "
" " of Nematognath Fishes.
" " of Plectospondylous Fishes.
" " of Osteoglossid "
" " of Pharyngognath "
" absence of Multituberculate Marsupial Mammalia.
" " of Orthopod and Goniopod Dinosauria.
" " of Plesiosaur Reptilia.
" " of Pterosaur Reptilia.
" " of Choristodere Rhynchocephalia.

The primary systems of the Cenozoic Realm are
Plistocene,
Pliocene,
Miocene,
Eocene.

Although open to conviction, I have not perceived the necessity for the term Oligocene for a supposed system between the Eocene and Miocene. In America the faunal distinction between the latter is so obliterated as to render a third name, for the present at least, unnecessary. I have also not adopted the term Quater-

* Prof. Cope objects to the word "Group" for the division of geological formations of the first rank and proposes to substitute the word "realm" therefor.

nary, since it implies what appears to me to be an erroneous classification. This classification makes the formations in question one of four primary divisions of geological time. To this position I cannot perceive that it is entitled on the evidence, which rather shows that it forms one of the systems of Cenozoic time. I use for it, therefore, the term Plistocene, and include in it all formations from the commencement of the drift to the most modern deposits inclusive.

The characteristic features of the faunas of these divisions are as follows:

EOCENE.—*Mammalia.* Presence of Tillodontia, Tæniodontia, Mesonychidæ, Amblypoda, Condylarthra, and Lophiodontidæ. Absence of Carnivora,* Ruminantia,† Proboscidia, Leporidæ, and Anthropomorpha (Europe). *Pisces.* Presence of Osteoglossidæ and Gonorhynchidæ.

MIOCENE.—*Mammalia.* Presence of Carnivora, of Rhinocerontidæ, Leporidæ, Ruminantia,* and of Edentata. Absence of Tillodonta, Tæniodonta, Amblypoda, and Condylarthra.

PLIOCENE.—Presence of extinct families of Mammalia: Castoroididæ, Glyptodontidæ, Megatheriidæ, and Eschatiidæ, and of extinct genera, as Holomeniscus and Hippotherium.

PLISTOCENE.—*Mammalia.* All families are recent and most of the genera; many species also recent.

Lithologically speaking, the Cenozoic formations of the interior of North America are much alike. They consist from the base of the Eocene to the base of the drift, exclusive of the latter, of layers of more or less calcareous, and more or less arenaceous, clay marls, interstratified with beds of impure and rarely hard sandstone. The arenaceous character increases with the lapse of time, so that the Ticholeptus Miocene is partly sandy, and the Loupfork Miocene consists almost exclusively of calcareo-arenaceous beds, alternating with nearly pure sandstones of varying, sometimes considerable, hardness. A hard sandstone is found in the Whiteriver Miocene. Of course the beds have the character of the shores of the basins in which they were deposited. Thus the material of the Johnday Miocene is shown by King to consist of the disintegrated volcanic ejecta of which the sur-

* One genus in the Diplacodon beds.

† I.e., quadritubercular Selenodont Artiodactyla. Two genera are found in the Diplacodon beds.

rounding land is composed. The cave deposits of the Megalonyx beds are of course highly calcareous. The Eocene beds, at least those of the Wasatch and Bridger series, resemble the Laramie in the abundance of small calcareous and ferruginous concretions which they contain.

EOCENE SYSTEM.

The Eocene formations of the interior of North America are as follows:

Diplacodon beds,
Bridger,
Windriver,
Wasatch.

These formations are clearly successive in their relations. There are two others, contemporary with one or more of these, whose characters are due to special physical causes. They are the

Amyzon beds,
Greenriver shales.

They differ from each other in the following faunal peculiarities:

WASATCH.—*Mammalia.* Presence of Tæniodonta, Condylarthra, and Pantodonta. Absence of Tillodonta, Dinocerata, Palæosyops, Hyrachyus, Amynodon, Achænodon, Triplopus, and suilline and selenodont Artiodactyla.

This formation is characteristic of the region between the Rocky Mountains proper and the Wasatches, and has three principal areas. The most southern is in Northwestern New Mexico; the middle tract is in Southwestern Wyoming and Northeastern Utah; the third tract is in Northwestern Wyoming, on the Big Horn River.

Thickness in Northwestern New Mexico (Cope),	.	2500 feet
Thickness in Southwestern Wyoming (Hayden),	.	1500 "
Thickness in Northwestern Wyoming (Wortman),	.	4000 "

WINDRIVER.—*Mammalia.* Presence of Condylarthra, Tæniodonta, Pantodonta, Dinocerata, Palæosyops, and Hyrachyus.

This fauna indicates the transition between the Wasatch and Bridger, since types are here associated which are elsewhere peculiar to the two horizons named. Thus, of the above zoological divisions the following are otherwise exclusively Wasatch: Tæniodonta and Pantodonta. The remaining ones are Bridger,

excepting the Condylarthra, which probably occurs in both Bridger and Wasatch.

This formation is known from one area, which is on the headwaters of the Wind River, near the Middle of Western Wyoming. The formation is, according to Hayden, not less than five thousand feet in thickness.

Near the horizon of the Windriver beds must be placed the Green River Shales. This formation intervenes between the Wasatch and Bridger beds in Southwestern Wyoming, and differs entirely from both in lithological and paleontological characters. It consists of more or less finely-laminated calcareous or calcareo-siliceous shales, which have a depth of two thousand feet. The sedimentation has evidently been fine, indicating deep and still water. The Vertebrata obtained are almost exclusively fishes, two species of Crocodiles being the only exceptions. The fishes are clearly of Eocene character, and embrace some types (Gonorhynchidæ, Osteoglossidæ, and Cichlidæ) now restricted to the Southern Hemisphere faunas. Two of these types, together with two other genera of fishes, occur in the Bridger beds; and the two last named (Clastes and Pappichtlys) are also found in the Wasatch. A probable second locality of this formation is known in Eastern Utah, in the Wasatch Mountains. The formation is known as the Manti beds.

BRIDGER.—*Mammalia.* Presence of Tillodonta, ? Condylarthra, and Dinocerata, Hyrachyus, Palæosyops, Amynodon, Triplopus, and Achænodon. Absence of Tæniodonta, Pantodonta, and selenodont Artiodactyla.

Two divisions of this formation are sustained by Scott. These have been named the Bridger and Washakie respectively by Hayden. The former is represented by a single area, which is west of Green River, in Southwestern Wyoming. The latter is also known from but one area, which is also in Southwestern Wyoming, but is east of Green River. These divisions differ in the species they contain, very few, according to Scott, being common to the two. Amynodon is the only genus which in the Bridger seems to be confined to the Washakie division; perhaps Triplopus has the same distribution.

Another tract of the Bridger formation is known from Western Colorado, but to which of the two above divisions it is referable is unknown.

The depth of the Bridger proper is, according to King, two thousand five hundred feet. I have given that of the Washakie as about twelve hundred feet.

DIPLACODON BEDS.—Presence of Mesonyx, Amynodon, Hyrachyus, Triplopus, Epihippus, Diplacodon, Xiphodontidæ (Protoreodon S. and O.), Poëbrotheriidæ (Leptotragulus), Eucrotaphus (Oreodontidæ, S. and O.), and Adapidæ (Hyopsodus Leidy). Absence of Amblypoda.

The facies of this fauna is remarkably intermediate between the Bridger below and the White River Miocene above. Genera found in the Bridger are Mesonyx, Amynodon, Triplopus, Hyrachyus, and Hyopsodus. Families which commence here and extend upwards, are Menodontidæ, Poëbrotheriidæ, and Oreodontidæ. According to Scott and Osborn, Amblypoda are wanting and Creodonta are sparingly represented. The connection which this fauna establishes between those of the Bridger and the White River is complete, as has been shown by Scott and Osborn.

One area is known. It is situated south of the Uinta Mountains in Northeastern Utah. The thickness of the beds is not great, according to King.

This series was named by King the Uinta, but as that name had been previously used by Powell for a Devonian formation, I adopt the next oldest term, which was introduced by Marsh.

AMYZON BEDS.—The exact horizon of this formation is not yet determined, but it is probably at the close of the Eocene or the opening of the Miocene. It is almost exclusively known paleontologically from fossil fishes, and these can be compared with those of the Green River shales. The characters are: Presence of Catostomidæ, Siluridæ, and Trichophanes. Absence of Osteoglossidæ, Gonorhynchidæ, and Chromididæ.

The only point of affinity with the Green River fauna is the presence of Trichophanes, which is nearly related to Amphiplaga of the latter.

There are three widely-separated localities of this formation. One is in the South Park of the Rocky Mountains, Colorado; another at Elko and Osino, in Northeastern Nevada; and the third is in Central Oregon, where it lies, according to Condon, immediately below the Johnday formation.

MUTUAL RELATIONS OF THE EOCENE FORMATIONS.—Where the Bridger beds rest on the Wasatch, which I know to be the

case only in the Washakie basin, in Wyoming, they are conformable. The Diplacodon beds are, on the contrary, not conformable to the Bridger beds, according to King. The relations of the Windriver beds to the Wasatch remain undescribed.

MIOCENE SYSTEM.

The formations of the Miocene in the interior of North America are the following:

Loupfork,
Ticholeptus,
Johnday,
Whiteriver.

These horizons represent succession in time. A formation whose relation with the Loupfork epoch is yet uncertain has been named "The Dalles." The four series each possess well-marked faunas, whose distinguishing features are enumerated below.

WHITERIVER.—*Mammalia.* Presence of a few Lemuroidea (?) and Creodonta, Metamynodon (Scott and Osborn), Hyracodon, Cryptoproctidæ, Poëbrotheriidæ, Tragulidæ, Elotheriidæ, and Menodontidæ. Absence of Felidæ, Ursidæ, and Rodentia, except Sciuridæ and Leporidæ; of Camelidæ, Equidæ, and Proboscidia.

There are three areas of this formation. The most extensive is the most southern, and occupies a large tract along the White River, in Northern Nebraska and Southern Dakota, and extends westward into Wyoming and southwestward into Northeastern Colorado. The second is much smaller, and is situated in Central Dakota, two hundred miles north of the nearest point of the southern tract. The northernmost Whiteriver formation is in Southern Canada, in the district of Assiniboia, and is intermediate in extent between the two previously-mentioned areas. Some faunal differences have been noticed between these areas, which may be due to geographical distribution, imperfect observation, or slight difference of age. Thus, in the Central Dakota area, Hyænodon, Hyracodon, and Poëbrotherium have not yet been found. In the Canadian tract neither of these forms has been found, and a genus of Creodonta (Hemipsalodon) is as yet peculiar to it. The thickness of the beds is as follows:

	Feet.
Nebraska (Hayden),	150
Central Dakota (Cope),	200

The Whiteriver series corresponds to the Oligocene of some authors. Thus there occur in both Europe and America at this period the genera Elotherium, Hyænodon, Cynodictis, Ischyromys (= *Sciuromys* teste Schlosser in litt.), ? Pterodon (? *Hemipsalodon* teste Schlosser in litt.), and Agriochœrus (? *Haplomeryx*). Other European Oligocene genera occur in the Johnday series, as Meniscomys (= *Sciurodon* teste Schlosser in litt.) and (? = *Aelurogale*) Archælurus (Schlosser in litt.).

JOHNDAY.—*Mammalia.* Presence of Nimravidæ, Poëbrotheriidæ, Tragulidæ, Elotheriidæ, Suidæ, Muridæ and Saccomyidæ. Absence of Lemuroidea and Creodonta; of Hystricidæ, Felidæ, Ursidæ, Camelidæ, Equidæ, and Proboscidia.

This formation occupies a considerable tract on the upper part of the course of the John Day River in Oregon. King states that it extends north into Washington and south into Nevada, but, according to White, the beds from the latter State, to which King gave the name Truckee, are of later age. According to Marsh the Johnday beds have a thickness of four or five thousand feet. The vertebrate fauna is very rich.

The beds in the valley of the North Fork of the John Day River present some faunal peculiarities, but their significance is unknown.

TICHOLEPTUS.—*Mammalia.* Presence of Anchitherium, Proboscidia, and Camelidæ, and the Oreodont genera Merycochœrus, Merychyus, Cyclopidius, and Pithecistes. Absence of ? Elotheriidæ, ? Poëbrotheriidæ, ? Nimravidæ, and Cosoryx.

This horizon requires further exploration, as but twenty species have been thus far determined from it. But it is evidently intermediate in age between the Johnday and Loupfork epochs, with greater affinities to the latter. It differs from the latter in the presence of Anchitherium and numerous genera and species of Oreodontidæ, and in the absence of Cosoryx. The formation is known from three regions: first, from Western Nebraska; second, from the valley of Deep River, Montana; and third, from Cottonwood Creek, Oregon. Its thickness has not been yet stated.

LOUPFORK.—*Mammalia.* Presence of Felidæ, Camelidæ,

Equidæ, Proboscidia, Cosoryx, Glyptodontidæ, and Hystricidæ. Absence of Tragulidæ, Oreodontidæ (with very few exceptions), Poëbrotheriidæ, Elotheriidæ, and Nimravidæ.

This formation has a wide extent throughout North America. The largest area overlies the Whiteriver beds in Nebraska, Wyoming and Colorado, extending south and east of that formation into Kansas, where it rests on the Cretacic. There is a second area in Northern Central New Mexico, and one perhaps in Southern New Mexico, extending from the Rio Grande to near the Arizona border. There is another tract in Washington County, Texas; and yet another in Mexico, on the boundaries of the States of Hidalgo and Vera Cruz. According to King its thickness in Wyoming reaches two thousand feet, but it thins out gradually to the eastward, so as to have a thickness on the White River of about one hundred and fifty feet, according to Hayden.

This formation was referred to the Pliocene series by King and Hayden, and I have called it Upper Miocene. The latter view is supported by the presence of the following European Miocene genera and species: Cosoryx, Blastomeryx; Castor div. Steneofiber; *Mastodon* (*Tetrabelodon*) *angustidens*. The remaining Oreodontidæ (Merychyus), give it a facies older than Pliocene.

This series has received the name of Niobrara from Marsh, a term previously applied to a division of the Cretacic. It includes the Humboldt, and probably the North Park formations of King.

PLIOCENE.

Under this head I include everything between the Miocene and the glacial epoch. It includes the following divisions. Two of them are consecutive in time, viz.:

Equusbeds.

Idaho.

Two others are probably contemporary with one or both of the preceding, so that the names have only a provisional utility.

Megalonyx beds.

Truckee.

IDAHO.—Present: Mammals, Camelidæ, *Equus excelsus;* Fishes, Cobitidæ, Percidæ, Siluridæ, Raiidæ, Mylocyprinus (Cyprinidæ), and peculiar species of existing genera of Cottidæ,

of Salmonidæ, Catostomidæ and Cyprinidæ. Absent: *Elephas primigenius*, etc.

The Mammalian fauna of this epoch is little known, owing to the rarity of remains. Its characters may be chiefly learned from the numerous fresh-water fishes it contains, by which it may be compared with the Equusbeds, which also contain many fish remains. But one area of this epoch is known. It covers the southern part of Western Idaho, entering Eastern Oregon.

TRUCKEE.—The typical locality of this formation is the Kawsoh Mountains in Western Nevada. The formation was supposed by King to be identical with the Johnday Miocene, but Dr. C. A. White informs me that it is of much later age. Vertebrate remains have been found, but have not been fully determined. Thickness (King), two thousand three hundred feet.

EQUUSBEDS.—Present: Glyptodontidæ (Mexico), Megatheriidæ, Eschatiidæ; extinct genera, Holomeniscus, Mastodon (Mexico), Smilodon (Texas); extinct species, *Elephas primigenius;* Equus, four species; Lutra, Cervus, etc.; recent species of Thomomys, Arvicola, Castor, Canis, ? Homo. Absent: Cosoryx, Oreodontidæ, Protolabididæ; Raiidæ, Cobitidæ, Mylocyprinus, and the fishes of the Idaho beds in general; Castoroides and Amblyrhiza.

The localities of this formation are widely distributed. In the presence of various extinct forms, above mentioned, it agrees with the Pampean fauna of South America, but differs in the presence of the northern existing genera and species with the extinct *Elephas primigenius.* The Argentine forms drop off successively as we travel northwards. Thus, Macrauchenia ceases in Bolivia (Huxley), Toxodon in Nicaragua (Leidy), Glyptodon in the valley of Mexico (Barcena), where *Elephas primigenius* commences. Where the line should be drawn between the Pampean and Equusbeds I do not know, but we can arbitrarily assume it to be the line of distribution of the *Elephas primigenius.* This will include the fauna of the valley of Mexico, which has also other forms common to the more northern area. Such are four species of Equus,—one of Bos, one of Eschatius, one of Holomeniscus (Camelidæ), and one of Platygonus.

The areas of the Equusbeds are, then, the valley of Mexico, Southwest Texas, Carson, Nevada, near Fresno, Southern

California, the Oregon Desert, Western Nebraska, and probably other localities. The beds are nowhere of great depth.

The presence of Homo in the beds of this epoch in Oregon was indicated by me in 1878. This discovery has been confirmed by the discovery of obsidian implements in place, in Western Nevada, as affirmed in a recent publication of Mr. G. K. Gilbert of the United States Geological Survey, in *Nature*. This gentleman has expressed the belief that the beds of this age are not older than the glacial epoch, because they embrace the basis of some of the moraines of some of the ancient glaciers of the Sierra Nevada. It remains to be proven, however, that these moraines are of true glacial age, since they are of entirely local character. The presence of so many mammals of the fauna of the valley of Mexico would not support the belief in a cold climate.

THE MEGALONYX BEDS.—This formation is chiefly represented in the caves of the Eastern States. Its fauna is as follows: Present: Megatherium, Mylodon, Megalonyx, Castoroides, Amblyrhiza, Arctotherium, Smilodon, Platygonus, Mastodon, of extinct genera; and of recent genera, Sciurus, Arctomys, Jaculus, Arvicola, Erethizon, Hydrochœrus, Lagomys, Lepus, Scalops, Procyon, Canis, Mustela, Equus, Tapirus, Dicotyles, Cariacus, Bos, Didelphys. Absent: Glyptodontidæ, *Equus crenidens, occidentalis*, and *barcenœi;* Eschatiidæ, Holomeniscus.

It is not certain that this fauna does not owe its peculiarities to geographical causes only, and was not entirely contemporaneous with the epoch of the Equusbeds. Its relations to that of the Plistocene are not yet fully defined.

PLISTOCENE SYSTEM.

The following report of this system in North America between the Allegheny and Sierra Nevada Mountain ranges has been drawn up by Dr. J. W. Spencer.

The southern limit of the Plistocene deposits—known as the Drift—is defined by a line extending from Long Island, irregularly northwestward across New Jersey and Pennsylvania into western New York; thence stretching in the form of lobes, across Ohio (to near Cincinnati), Indiana and Illinois, to near St. Louis. It then sweeps round and forms a comparatively narrow zone upon the western side of the Missouri River—to which

it is parallel—and extends northwestward towards its head waters, and crosses into Canada at the east foot of the Rocky Mountains.

There is also a southern drift (Orange Sand, etc.), in the valley of the lower Mississippi and in the Gulf States, whose relation to that of the north is not yet fully explained.

In the interior of the Continent, the Plistocene deposits often rest upon glaciated rock surfaces, which have not been defaced by weathering. These are best developed in the lake region or over areas radiating therefrom. The general direction of the striation is to the southward, radiating from the basin of the Great Lakes, (whose greatest depths are mostly from 750 to 1026 feet). From the valley of the Ottawa River to that of the St. Louis—southwest of Lake Superior—the direction of the striæ is traceable across the deep lake basins, over the highlands—separating the lakes from the arctic drainage (at no greater altitudes than the more southern hills)—to a common centre in the great broad open basin of Hudson's Bay, 1600 feet or more below the glaciated hills to the south. The same phenomena hold true for northwestern Canada, where the movement was from Hudson's Bay, or the more southern low plains, toward the higher Coteau de Missouri and higher plateaus, at the foot of the Rocky Mountains.

The deposits may form vast irregular sheets of clay, sand, gravel or boulders; may assume the form of great ridges of the same materials, having a thickness of even 500–700 feet (exclusive of that filling buried valleys); or may be in regularly stratified beds. Some of the Plistocene deposits are of wide extent. The positions of others more or less disconnected, are often difficult of correlation, on account of their changing characteristics, or our imperfect knowledge of them. This difficulty is increased owing to a variety of results being produced simultaneously by different agents; and even here geologists are not agreed as to the causes. Consequently only the more important series of the Plistocene system are provisionally given. In ascending order:

6. Terrace and Beach.
5. Saugeen clay.
4. Erie clay.
3. Upper Drift or Till.
2. Vegetal bed.
1. Lower Drift or Till.

The Lower and Upper Drift series are more or less alike in composition, but they are in many places separated by soils holding the remains of rich vegetation. Each of the series of the Drift is of itself of complex structure, with even intercalated layers holding plant remains. The Drift is most commonly composed of clays often containing glaciated stones with various admixtures of sand, or sometimes considerable quantities of boulders. A minor proportion of these materials has been transported from a distance. These deposits often show no, or only obscure, stratification; yet this structure may be developed, or it may be present in the form of included beds of clay or sand.

The Lower Drift is in the form of irregular sheets, which may be regarded as composed of two separated series, above the upper of which the Loess of the Mississippi has been placed. This obscurely stratified, or not stratified, fine, homogeneous, calcareous sandy clay contains land and fresh water shells and bones of mammals. The Upper Drift is more commonly in the form of moraine-like ridges, of great extent, developed in lobes, especially in front of the Great Lakes. However, these ridges are apt to be capped by more or less irregularly stratified deposits of clay, sand or gravel. Such hills form many of the well-known "Hog-backs" of the Drift region.

The Erie clay is best represented in the Lake region, and is a well stratified, generally stoneless blue clay, derived from the older Drift. It also includes some stony stratified clays. Its surface is extensively denuded, and upon it rests the more sandy yellow and brown Saugeen clays (a name including a group of clays). These stratified deposits of the interior of the Continent are probably the equivalents in part of the more eastern marine Champlain beds. However, their exact relationship has not been made out. Some of the beds included here are doubtless the deeper lacustrine equivalents of some of the beaches of the next series.

The Terrace and Beach series embrace a large group. Some of the terraces date back to the earlier Plistocene period, and are represented by sea-cliffs cut out of the older rocks. Newer terraces are cut in the softer materials of the Plistocene beds. There are also terraces of construction and numerous beaches of sand and gravel. The terraces are most strikingly developed in the river valleys; the beaches (with associated terraces) about the

lakes, whose former margins, now often far inland, they represent. In the Great Lake region, they are known to occur at various altitudes, from 1500 feet, or more above, down to the sea-level. Most of the scattered surface erratics belong to the Beach or Terrace series, having been chiefly derived from the older boulder clay. All the Plistocene formations have been deformed by the continental oscillations and warpings subsequent to their deposition. The warping or differential elevation of the earth's crust about the Great Lakes, since they formed one body of water (Lake Warren), varies from almost zero to five feet or more per mile. The effects of the Plistocene warpings have been to deform the old valleys and cause changes in the drainage (besides those from drift obstructions) and to bring to the surface rocky barriers, which, in part, close the older Cenozoic valleys of the Great Lake region, and convert them into lake basins. This phase is still one of the newer studies of Plistocene Geology. In the beaches, Mammoth, Wapiti, and Beaver remains, have been found. Fresh water shells are positively known to occur only in the lower beaches about the different lakes, and shell-life of any kind appears to be absent from all the higher shore deposits. However, in passing from the lakes to the St. Lawrence Valley, marine remains are found at increasing altitudes, in proceeding eastward—those at Montreal occur at 520 feet above the sea, and others at still higher elevations farther seaward.

Other lake deposits are found beyond the region of the Great Lakes, as those of the Red River Valley of the North (Lake Agassiz). Between the Wasatch and Sierra Nevada Mountains, alluvial and marly beds, belonging, in whole or part, to the Plistocene System, are of wide extent. These beds were deposited in lakes now extinct or shrunken, of which the two best known and largest are Lake Bonneville (of which Salt Lake is a remnant) and Lake Lahontan (shrunken to Carson Lake). The terraces show recent differential changes of level, as in the Great Lake region.

NOTE ON THE CENOZOIC SERIES.

The Geology of the Uinta Mountains, by Major J. W. Powell, appeared, according to the date on the title page, in 1876, one and two years prior to the vols. II. and I., respectively, of the Reports of the Surveys of the Fortieth Parallel, by Captain Clarence King. It is necessary, therefore, to ascertain whether any of the names proposed in the former work antedate those of the latter. The Cenozoic series for the region in question, admitted by Powell, are the following, in descending order:

Bishops' Mountain Conglomerate, 300 feet.
Brown's Park, 1800 feet.
Bridger, 2000 feet.
Upper Green River, 500 feet.
Lower Green River, 800 feet.
Bitter Creek, 3000 feet.

The Bridger of this section is the Bridger of Hayden, or the Middle Eocene, and the Green River beds are also those so-called by Hayden. Above this series the Brown's Park division is in the place of the Uinta of King, for which I have used in the preceding pages the name Diplacodon beds of Marsh. No vertebrate fossils are reported from this formation by Powell, so that it is not possible to be sure whether the formation is the same as that described by King or not. The typical locality of the latter is not mentioned by Powell. Should it prove to be the same as the Uinta formation of King, the name Brown's Park series must be retained, as having priority of publication.

THE BISHOPS' MOUNTAIN CONGLOMERATE is a late formation which covers the Eocene beds of Southwestern Wyoming unconformably. Its exact age has not been yet ascertained, as it contains no fossils. Powell remarks that it has the appearance of a glacial drift, but he prefers not to consider it as due to such a cause without further evidence. It is described by Endlich, in Hayden's Annual Reports, as the Wyoming Conglomerate. I do not know which name is prior.

Below the Green River beds comes, in the above section, the Bitter Creek group of Powell. This is, from the description, as well as the author's admission (p. 65), the Wasatch of Hayden, which latter name has priority. In describing it Major Powell (p. 47) states that the Pink Cliffs of Southern Utah belong to it. The Puerco series is not mentioned.

E. D. Cope.

Report of the Sub-Committee on the Quaternary and Recent.

C. H. HITCHCOCK,

REPORTER.

AMERICAN geologists have usually followed their European brethren in the use of the general terms Quaternary, Post-Pliocene or Plistocene, when describing Post-Tertiary terranes. The use of Alluvium in a similar sense is mostly given up because it seems to imply the absence of ice as an important agent. When local deposits are described, most authors have employed designations of limited application, and the term Champlain is almost the only one that is extensively used. Recognizing the fact that the Quaternary embraces every kind of formation, it is clear that the names of the divisions, whether of a geographical or lithological character must be very diversified. A terminal moraine in Wisconsin may be cöeval with a delta in Louisiana, a lake terrace in Nevada, a coral reef in Florida, a phosphate bed in South Carolina, a sand dune in North Carolina, or a bed of marine sand in New York. Each section of the country has a peculiar set of deposits, but all embraced within the general term of Quaternary or Plistocene. Inasmuch as the distinction between the Plistocene and the Pliocene terrane depends upon the percentages of extinct species of marine mollusca, the typical beds must be found along the sea shore. The sea is always present while the ice-sheet covered only a part of the land.

The Atlantic Coast.

Beginning with Florida, according to Dall, Heilprin and E. A. Smith the Pliocene is at present overlaid by the *Venus cancellata*

limestone, *Vermetus* limestone and *coquina*. The latter is found upon both the east and west coasts, with a great thickness at St. Augustine. Upon the land both the coquina and Tertiary terranes are universally covered by sand, often nearly pure silica, and one hundred feet thick, nearly as far south as Lake Okeechobee. The tufas from springs are limited in extent. The coral-reef limestone lies entirely to the south of latitude 27°.

In Georgia the upper member is a mixture of clay, sand and peaty matter, 12 feet thick, containing the bones of Megatherium and other terrestrial mammalia, and is underlaid by sand several feet thick containing living species of mollusca.

In South Carolina, Tuomey speaks of Post-Pliocene 60 feet thick, elevated eight feet above tide water, extending ten miles inland and abounding in marine shells of living species. Holmes describes the terrane as consisting of three parts, clays and sands, including much of the phosphate deposit, since so celebrated, and containing 150 species of shells, all but two recognized as living species. There were also many mammalia.

Kerr's latest conclusions ascribe a thickness of 200 feet to the Quaternary of North Carolina. W. J. McGee is the latest writer upon the Atlantic coast Quaternary, and cites the views of W. D. Rogers and W. M. Fontaine for Virginia, P. T. Tyson for Maryland, J. C. Booth and F. D. Chester for Delaware, H. C. Lewis for Pennsylvania, H. D. Rogers, G. H. Cook, E. D. Cope, F. J. H. Merrill and N. L. Britton for New Jersey, W. W. Mather and Merrill for Long Island, Sanderson Smith for Gardner's Island, E. Desor and A. E. Verrill for Nantucket, and the first named for Point Shirley near Boston.

McGee's personal studies relate chiefly to the coast between North Carolina and New York, and he establishes first the "Appomattox formation," which he evidently regards as Tertiary, though correlating it with a part of the Orange Sand of Hilgard. It is composed of orange-colored sands and clays, with a maximum thickness of 100 feet. Second, the undoubted Quaternary is called the "Columbia formation" from its occurrence in the District of Columbia. It is identified with the deposits along the Atlantic coast described by the author cited, from South Carolina to Point Shirley, all of which are newer than the Tertiary. A further conclusion is that it is "much older than the terminal moraine or the drift sheet whose margin it marks,"

because it underlies the drift sheet, the erosion has been greater and the oxidation is more thorough. The formation is the littoral part of a submarine deposit from the Roanoke to the Delaware, thus indicating a submergence of 100 feet on the Roanoke and 450 feet on the Delaware. The upper part is brick-clay and loam; the lower, gravel, sand, and boulders. The author finds evidence that the Columbia formation corresponds to the first glacial epoch; that the two glacial epochs were separated by a very long non-glacial interval, which may have been ten times as long as either of the cold terms and five times as long as the post-glacial epoch. He differs from Chamberlin in his estimate of the place of the Loess, believing it to have been connected with the second till.

Following the Quaternary marine deposits farther north, the reporter finds the first deposit containing boreal or Labrador shells at Gloucester, Mass., which is overlain by till. Very clear evidence of the relations of the fossiliferous beds to both tills is found at Portland, Me. Here clays and sands rise about 100 feet above the sea and hold 121 species of organisms, all of living forms. They rest upon typical lower till, and are overlain by as much as 50 feet thickness of upper till. At the time the reporter described these facts the prevalent doctrine of the triple nature of the glacial period had not been established; but it seems clear that two seasons of ice-presence are indicated at this locality. Further east, in Maine and New Brunswick, the occurrence of these fossiliferous clays is abundantly proved in the writings of various local geologists. No Plistocene with marine shells has been reported as yet from Nova Scotia. The boulder clay is underlain by a peaty bed. In Labrador, A. S. Packard, Jr., has described numerous molluscan remains in deposits up to the height of 600 feet.

Sir William Dawson has thoroughly studied the Quaternary of the St. Lawrence valley, and has catalogued 205 species of animals and plants found fossil, all of them identifiable with living species. About 100 of the species are also named in the Portland list, showing the contemporaneity of the beds. Following the distinction indicated by C. B. Adams he calls the lower beds with pelagic species *Leda clay*, and the upper beds with littoral species, *Saxicava sands*. As he allows, both may have been in process of growth at the same time, so that these are not

necessarily two time divisions. The highest locality of fossils is at Murray Bay; on the north side of the St. Lawrence, 600 feet, and at Montreal the height is 520 feet. At the first locality the marine beds connect with sands and gravels washed out of the till of what Dawson concedes to have been a glacier, running S.E. At Little Riviere du Loup the fossil beds are capped by a deposit containing boulders 15 feet through. In Vermont the marine clays nearly reach 400 feet above the sea, and received from the reporter the name of Champlain in 1861. E. Desor had still earlier proposed the name of Lawrencian for these beds; but as the closely related name of Laurentian had in the meantime been applied to the most ancient crystalline rocks by Sir W. E. Logan, and almost universally adopted, it seemed best to the reporter to suggest the name of Champlain from a typical locality in his field of labor. Both authors agreed that these marine beds overlay the unmodified drift (lower till) and hence were cöeval with the tumultuous aquatic deposits of the later Quaternary.

Before this time E. Desor claimed that the Lawrencian beds were the equivalent of the Post-Pliocene of the South, and that the most northern relic of the Post-Pliocene was at Pt. Shirley. Using Dr. A. S. Packard's terms, the *Virginian fauna* which now does not pass Cape Cod, extended to Pt. Shirley, where it was replaced by the *Syrtensian* or Labrador fauna, not now found on the shore south of northern Newfoundland. The present Acadian fauna, now prevailing from Cape Cod to Cape Breton, was recognized by Packard between Saco River and Pt. Shirley. The southern extension of the Labrador climate was due to the land ice.

The reporter believes the following conclusions to be legitimate: 1. The Plistocene of the South and the Champlain beds of the North are identical, just as the Virginian, Acadian and Syrtensian faunas of to-day are identical. The animals now vary specifically because of different physical conditions. 2. The southern deposits may represent the whole of the Plistocene, and so may the Champlain, since it underlies till in Massachusetts, is interglacial at Portland, Maine, and is usually superior to the boulder clay in the St. Lawrence valley. 3. The lowest till does not represent the beginning of the glacial age, since a long time must have elapsed before the ice could have reached its southern limits from its remote origin. 4. The land was depressed in

the ice age rather than elevated. 5. The Long Island ridge represents the extreme southern margin of the ice sheet. 6. The agency of icebergs and shore-ice in producing boulder clay is conceded for the lower St. Lawrence valley as high as the Saxicava sand.

Lower Mississippi Valley.

The enormous mass of sediment discharged into the Gulf of Mexico by the Mississippi river, and the situation of the upper part of the hydrographic basin so as to collect the water derived from the melting of the ice-sheet, give peculiar and, in one sense, typical Plistocene deposits. Prof. T. C. Hilgard has given a summary of ten years' study of them.

At the base, Orange sand or stratified drift, 60 to 100 feet thick, supposed to be the equivalent of the northern till. Second, the Port Hudson swamp and littoral deposits, from 30 to 630 feet thick, supposed to be the equivalent of the Champlain period as defined by Dana. Third, Loess or Bluff, and Loam, 50 feet. Fourth, Alluvium and mudlumps, 30 to 70 feet.

The Orange sand has a large development in Mississippi and Alabama, being most abundant at the present heads of navigation in the rivers, where the highlands begin to rise noticeably. It is analogous to a flood-plain deposit, some of the material having been carried 60 to 80 miles in Alabama. Tuomey was the first to suggest some affinity of these sands to the northern glacial deposits, and conjectured that they might be traced as far north as Baltimore. This would seem to be confirmed by the observations of McGee in the establishment of the "Appomattox formation."

Quaternary of the Interior.

Since the discovery of the two lines of terminal moraines from the Atlantic to Dakota, the science of Surface Geology has fairly been reconstructed. No organization has accomplished so much in this direction as the United States Geological Survey. Without tracing the various stages of discovery, it will be sufficient to give the latest conclusions of Prof. T. C. Chamberlin as to the events and order of deposits. The table is somewhat abridged. The transition epoch from the Pliocene is not yet satisfactorily distinguished.

Epochs.	*Sub-Epochs or Episodes.*	*Attendant or Characteristic Phenomena.*
Earlier Glacial Epoch.	First sub-epoch, .	Drift-sheet, with attenuated border, scanty marginal drainage.
	Interglacial, . .	Ferruginated, etc.
	Second sub-epoch, .	Loess.
Chief Interglacial Epoch.		Elevation of Upper Mississippi region, ± 1000 feet.
Later Glacial Epoch.	First episode, . .	Till-sheet, bordered by Kettle Moraine.
	Deglaciation, . .	Vegetal deposits.
	Second episode, .	Till-sheet, bordered by the Gary Moraine.
	Deglaciation, . .	
	Third episode, .	Till, bordered by the Antelope Moraine.
	Later stages, . .	Marked by terminal moraines.
Champlain Epoch.		Marine Champlain, lacustrine deposits about Great Lakes.
Terrace Epoch. .		Fluvial excavation of flood plains of second glacial epoch.

The glacial lakes Agassiz, Bonneville and Lahontan are noticed elsewhere, also the region of the great lakes. On the Pacific coast the Plistocene marine beds have about the same bulk as those on the Atlantic. There are, besides, immense lacustrine beds in the valleys of the Sacramento, San Joaquin, Willamette, etc. Possibly the sands and gravels may be thousands of feet thick in some of the valleys. The auriferous fluviatile deposits on the slopes of the Sierra Nevada are regarded as Pliocene by J. D. Whitney. The evidence of feeble glacial action in the Sierras has been described, and the glaciers still remain.

The flood plains of the river valleys, out of which terraces have been carved, are composed of material derived from the till and deposited rapidly in water swollen to enormous volume by the melting of the ice. Towards the mouths of the rivers they may merge into marine deposits after reaching the level of tide water. Elevated beaches cannot be regarded as oceanic in the absence of marine fossils.

Recent.—The term *Recent* is understood to embrace every kind of rock that is now in process of formation, and when described systematically each one is referred to its origin, whether marine, estuarine, lacustrine, fluviatile, torrential, glacial, æolian, subaërial and terrestrial. Upon maps of small scale it is not practicable to represent these classes separately. Upon maps of a large scale every author uses his own symbols and devices. It is often convenient, where the underlying rocks are concealed by either recent or quaternary deposits, to use the general designation of Plistocene for the covering mantle. *Recent* might be regarded as nearly synonomous with *Historic*. We have as yet no distinctively American classification of the deposits representing the geological history of man.

CHAS. E. WRIGHT,

Late State Geologist of Michigan.

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SKETCH OF THE LIFE AND CHARACTER OF CHARLES E. WRIGHT, LATE STATE GEOLOGIST OF MICHIGAN.

By C. D. LAWTON.

THE cause of science met with the loss of one of its most accomplished votaries in the death of the subject of this memoir which occurred in Marquette, Mich., on the 22d of March, 1888. In no way could the country suffer greater injury than by the loss of men such as he. He has fallen in the prime of life, in the midst of his manifold labors, too early for the full rounding of his fame. His plans for the work on which he was engaged were of a broad and liberal character and had he lived to fulfill them, would have brought lasting honor to himself and have been of inestimable value to the State and to the world.

The election of Mr. Wright as the director of the Geological Survey was most fortunate for the cause of science and for the practical interests of the State. His training in Europe and his long experience in the field and laboratory, rendered him peculiarly fit for the post of state geologist. His whole life from boyhood to the day of his death, had been a preparation for the work which he was allotted to perform. He exemplified the highest training which this century affords for the particular field of scientific inquiry in which the line of his industry lay; he had studied in the best schools in the world, had enjoyed the instruction of the most famous teachers, had worked in laboratories, in furnaces and in mines; he had sought information in the great metallurgical works and mines of England and on the continent of Europe; and withal he was endowed by nature with uncommon powers and enthusiasm for the work which he had chosen and with an industry and zeal that never

flagged. When a mere boy he was an enthusiast in science and had become an original investigator. In his father's house he had a laboratory and, almost self-taught, he had been able to make many analyses, and to become expert as a machinist and inventor.

Mr. Wright was born at Copenhagen, Lewis Co., N. Y., Oct. 7th, 1843, in the same house in which his father had also first seen the light of day. His father's parents had come into the region at an early date from Connecticut, where their ancestors had been among the first settlers. His mother's grandparents had emigrated from Rhode Island where the names of their proprietors appear in the primary records of that diminutive colony. The grandfathers of both his father and his mother were soldiers in the patriot army in the first war for independence. Every drop of his blood was as purely American as it is possible that it could be derived, and his character was true to every loyal instinct of his race.'

His father led a useful life, distinguished for his probity and good judgment, and his mother was a person of singular amiability and good sense. Far and wide, among kindred and friends, they were both greatly beloved and their home was a favorite resort, where all found ready welcome.

Mr. Wright was fortunate all his life in his home; none was happier than the home of his childhood and none more congenial than the home of his married life.

After completing a course in civil engineering, Mr. Wright became city engineer at Auburn, N. Y., where his parents resided and he was noted for the rapidity and accuracy of his work; but in addition he did chemical work, practiced telegraphy and gave attention to applied mechanics and machinery. Subsequently he familiarized himself with the metallurgy of iron-making, at the Pioneer and Lawton furnaces, located respectively at Negaunee and Lawton, Mich., where he was engaged during 1866-7, thence going to the Red River iron works near Lexington, Ky., where he remained as chemist and engineer for two years. The company operated both mines and furnaces and the experience which he obtained here was varied and valuable.

Mr. Wright determined to carry out the plan which he had long entertained of going to Europe to pursue his studies. He

had acquired a good knowledge of the German language and his previous study and experience led him to know what he most wished to acquire.

He studied first at the university of Berlin, where he became proficient in the use of the microscope in determining minerals, then a new feature in mineralogical work, which at that period had not been introduced into this country, his subsequent papers, in which this subject was introduced, being among the very first published in the United States.

From Berlin he went to Freiburg to include some special studies, and afterward visited the mines and great metallurgical works in Germany, Sweden and England.

Having thus spent three years abroad, he returned to America in 1873 and was immediately employed by Mr. Clarence King, Director of the U. S. 40th parallel survey, in making rock sections and determinations for the survey. While abroad he had also made the determinations of the suite of specimens for the Michigan geological survey which work was afterward gone over and endorsed by the celebrated lithologist Von Cotta.

In June of the same year of his return, Mr. Wright opened an office and laboratory in Marquette, Mich., where he thenceforth made his home. He was successful from the outset. Skillful, accurate, kind and obliging, his services were in full demand and he speedily became the unquestioned authority on all scientific matters pertaining to the lake Superior iron ores. He found time to make an examination for the State of Wisconsin, of a portion of the Penokee iron range and his paper on that subject forms a valuable chapter in the state geological report.

At the session of the Michigan Legislature in 1875–6, the office of commissioner of mineral statistics was created and Mr. Wright was appointed to the position, which he held until 1883. The volumes that were published on the mineral resources of Michigan during this period, were esteemed of great practical value and have received the highest praise from mining men and geologists everywhere. Four years ago Mr. Wright accepted the office of state geologist and he forthwith devised a plan or rather he matured one, which had grown out of his long experience and intimate knowledge of the country, for a systematic geological survey of the upper peninsula and of the state.

His plan embraced a careful examination of the entire mineral region of the northern peninsula, section by section, tracing the rock formations, noting all outcrops and their geological features, the magnetism, topography, collecting and marking specimens, &c. All these details were carefully mapped. The specimens were catalogued and referred by co-ordinates to the corner of the section from which they were obtained, and were determined under the microscope by making sections of them, and the mineral characteristics were fully set down in the catalogue.

Every specimen of the many thousands which he had is thus described and referred to the map of the township in which it was found. By opening the volume of plats and turning to the particular one required, we find indicated on it the point where the specimen was obtained, and also find a sketch of the formation, and of the topography, and elsewhere have a statement of the physical features of the formation. In this manner he had examined the iron region from range 25 westward to range 34, and during another season it was expected to cover the country to the Gogebic iron range, and possibly to include that also and reach the Montreal river, the western boundary of the state. In addition to this work done in the lake Superior district, Mr. Wright began in 1885 to collect the records of the deep borings that have been made in the state for salt and for gas; he had arranged with parties who were engaged in sinking wells to save for him samples of the several strata passed through, taken at each few feet in descent. Of some of these, where he had collected the data, he was able to construct geological diagrams showing the different strata passed through. One practical value of these sections is, that they enable parties to compare the results of their own drilling, from day to day, with the sections of borings made, perhaps, in their vicinity, and thus to form an intelligent idea as to where they are geologically, and when they may expect to reach the horizon where gas or salt was found in other wells. Scientifically these borings, thus made in various parts of the lower peninsula, afford the finest possible data for geological cross sections; giving us an idea of the structure of the rocks underlying the southern peninsula of Michigan.

Intensity of application to his work through many years had

undermined a naturally robust constitution and for several years past, Mr. Wright and his immediate friends became aware of his failing health, and that a relaxing from the great mental labor which he was undergoing had become imperative. Such a course he himself held in contemplation and it was his intention to indulge, in the near future, in a partial relaxation from labor. Since early in January last he had been in Baltimore at the Johns Hopkins university with his rock sections and microscopes, pursuing his investigations. Finally he had completed his determinations, was confident of his results and set out on his return home to begin the agreeable task of putting his data into shape for publication, when death overtook him so suddenly and so untimely. Taken with a severe cold on his journey, he reached home to survive but a few days.

His memory is enshrined within the hearts of all who knew him; and to all he leaves the record and example of a noble, industrious, well spent life. Those who were so fortunate as to know him well, loved him for his simplicity of character, for his integrity and his adherence to truth. He was the symbol of honesty and truth, an example of pure and virtuous conduct. He sought the highest attainment in a complicated department of pure science and he had reached far upward toward the summit of the pathway along which he had striven.

NOTES ON THE STRUCTURAL GEOLOGY OF THE CARBONIFEROUS FORMATION OF PENNSYLVANIA.

By Henry A. Wasmuth, M. E.

The second geological survey of Pennsylvania advocates the theory that the anthracite seams have been plicated into synclinals, anticlinals and inversions without fracture and dislocation. The minute local variations, or irregularities in the incline of the Pittsburgh coal beds are assigned to a change in the bulk of each coal bed, and without connection with the great system of anticlinal and synclinal plication of middle Pennsylvania.

A glance at the maps of the middle and southern anthracite fields of Pennsylvania, constructed by the second geological survey of Pennsylvania will convince one, that by the horizontal mine workings (levels) on different coal seams, numerous

plications have been developed, and that these plications, the underground contour lines, and some of the cross sections produce startling effects. It is true, the maps of the second geological survey of Pennsylvania, to a certain degree are re-constructions of the mine maps, but the objects of the survey as expressed have been: "to afford means to mining engineers and superintendents to direct their headings, etc.;" but I venture to say, that the survey has failed to realize these objects, and I will this prove by the following:

In "bedded" mineral deposits no "inversion" or "over-lapping" of the strata can take place without fracture and more or less dislocation, and in general, the dislocations of the strata take place in one of two ways; either the portion of a mineral deposit on the hanging wall of the fracture or fault is in a lower position than the portion on the foot wall, as illustrated in fig. 1, or it is in a higher position as illustrated in fig. 2. Occurrences such as those illustrated in fig. 1, are called "transverse faults," while those in fig. 2, are called "longitudinal faults," or "over-laps," or "folding faults."

Fig. 1.

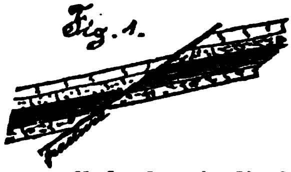
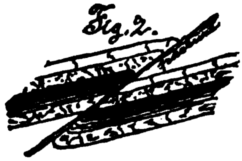


Fig. 2.



These general theories of "faults" have been established by long experience in mining in Europe, and are described in the report of the first geological survey of Pennsylvania, which contains an illustration of a longitudinal fault, in the blue slates near Wormleysburg, (section of the Kittatinny valley).

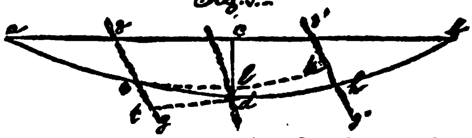
The second geological survey of Pennsylvania has indicated a probable "line of fault" on its maps of the Shenandoah region.

All exposures of the Carboniferous formation, even in localities where it is developed incompletely, or even where it is wanting, are of the same geological age, and originally have been in a nearly horizontal position. Every change of the formation, (or its members) from the original horizontal position, in a geological point of view, is termed a "disturbance." It must be assumed that the first disturbance of sedimentary rock from the horizontal position commenced with the origination of shallow anticlinals and synclinals, either by a "lifting" or "sinking" of the strata and consequent lateral thrust. I adhere

to the theory that the origin of synclinals and anticlinals is a natural consequence of active volcanoes, which has been produced by sinking of parts of the earth's crust. These theories demand inquiring into the state (plastic or hard) of the strata and coal beds at the time of the disturbance from their original horizontal position. From the facts developed, especially in coal mining, it is undoubted, that the rock and coal at the time of the disturbance from their original horizontal position, have been as hard as they are to-day. I might for convenience add, that geologically, each stratum has three extensions, two of which, (its length and breadth) are predominant, while the third extension, the smallest one, is the thickness of the stratum.

If, for instance, the distance *a*, *b*, fig. 3, across a small synclinal of a coal seam, is 30 feet, and its depth *c*, *d* is one foot, then the line *a*, *d*, *b*, is about 30.4 feet long. If the coal bed in its horizontal position has been 5 feet thick, and if it had been in a plastic state at the time of the disturbance from its original horizontal position, then the substance 30x5 must have been thinned out to about 30.4 feet long, and the present thickness of the coal seam in the synclinal should be about 4.93 feet; but out of 100 of such occurrences in the Pittsburgh coal bed, in at least 90 occurrences the lamination and thickness are absolutely undisturbed and we find almost always that the coal bed has been disconnected by fracturing, at least once, in the length *a*, *d*, *b*. It must be assumed that at the time of the disturbance referred to, the coal bed was overlaid by its present roof rock, and from the facts, of the origin of the synclinal in connection and the weight of the roof rock, the lamination and thickness of the seam have not been affected at all, but since there has resulted a fracturing of the coal and country rock (roof and floor), it must be concluded that the strata were hard.

Fig. 3.

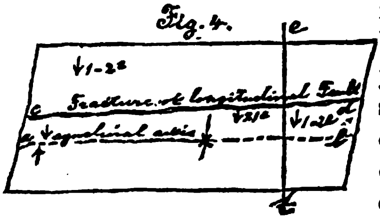


This will be proven by the facts; if for instance, the fracture appears in the neighborhood of the synclinal point *d*, sometimes the parts *a*, *d*, and *b*, *d*, of the strata are bent slightly downward, toward the fracture without apparent dislocation; the fracture shows its original projections and it is filled with

disintegrated rock, etc. A close examination of workings in coal mines will convince one, that the coherence of strata in many instances is sufficient to permit of the slight bending of coal and rock for a greater or less distance, without fracture. If for example, the fracture *g*, *g*, appears as indicated in *e*, fig. 3, the dip (hade) of the fracture is in the direction of the dip of the strata, but steeper. Such occurrences generally show that the part *a*, *e*, of the coal bed has not been curved; it resisted bending and sinking by the underlying strata, but then by the force of gravitation the part *e*, *b*, of the coal bed has slid down as indicated by *f*, *b*, fig. 3, frequently without bending that part of the strata. The fracture always is filled with disintegrated rock, consequently a "rock-lode," and if the general terms "hanging-wall," "foot-wall," etc., are applied to it, we have a fault (disconnection and dislocation), whereby the part of the strata on the hanging wall of the fault is in a lower position than the part on the foot-wall. Such faults are termed "transverse faults" (fig. 1). If the fracture *g*' *g*' appears as indicated in *h*, fig. 3, then the dip of the fracture is contrary to the dip of the strata, showing similar effects of the dislocated parts of the strata as before indicated by *a*, *l*, *k*, and *b*, *h*. Such occurrences are termed "transverse faults with contrary dip."

Another dislocation is illustrated in fig. 4. The line *a*, *b*, represents the synclinal axis, not located yet, and *c*, *d*, the fracture, which is developed for length of more than 1,000 yards in the Westmoreland shaft. The average dip of the coal bed in the neighborhood of the fracture is about 1 to 2 degrees and the cross-section *e*, *f*, fig. 5, approximately would be as indicated.

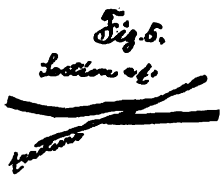
Fig. 4.



The strike of the fracture probably is nearly in the course of the synclinal axis, and the part of the strata on the hanging-wall of the fracture is in a higher position than the part on the foot-wall; the portion on the foot-wall of the fault has slid down, thus originating a complete and distinct over-lapping of the coal bed of about 6 inches; the fracture is about 2 inches wide and it is filled with disintegrated coal, probably on account of the slight sinking of the strata and because only coal surfaces have

rubbed upon each other. Such faults are termed "longitudinal faults," or "over-laps," or "folding faults," (fig. 2).

Faults, as described before, have been met with numerously in the Pittsburgh coal bed, but transverse faults there predominate, perhaps on account of the general character of the gently plicated flexures of the most frequent and more or less deep synclinals. All fractures of the coal bed developed thus far run up high into the roof rock, and naturally the fracturing of hard rock and coal produced uneven, rough planes; but the projections have disappeared entirely; the sinking of one part of the broken strata, or even disproportionate sinking of both parts produced friction; thus the planes of the fracture, although curved more or less, have rubbed each other smooth and polished (sometimes with distinct striation), and the bulgings of the fracture are filled with the disintegrated projections caused by fracturing. The different occurrences of faults show also that the fracturing of the strata took place when its sinking commenced.



Had the strata been in a plastic state at the time of the disturbance from their original horizontal position, no results as described before could have been originated, for the enormous weight of overlying strata in connection with fracture would have produced a squeezing of the different substances into each other and the fractures would not be filled with disintegrated rock, sometimes pure clay; and therefore no such inversions as those constructed by some mining engineers and supposed by the second geological survey of Pennsylvania to occur in the anthracite measures exist; their existence is impossible, because the strata were hard at the time of the disturbance from their original position.

The Pittsburgh coal bed, or rather the Carboniferous formation, or even members of it, have been in a nearly horizontal position, and dislodgment of interior masses of the earth by volcanoes, etc., must have caused a greater or less sinking of parts of the earth's crust without any regularity, thus originating a combination of synclinals and anticlinals of varying areas and depths. Parts of these anticlinals disappeared by erosion and thus we find the present synclinals of the coal bed more or

less separated; and the gently dipping flanks or flexures of the synclinals must be assigned to the areas, involved by a special synclinal or anticlinal of comparatively small depth.

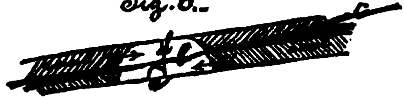
The anthracite measures of Pennsylvania are distorted enormously. (See maps of the second geological survey of Pennsylvania.) The greater portion of the anticlinals has been swept away by erosion, thus separating a number of synclinals. The synclinals mostly are long and narrow, the result of enormous lateral thrust; consequently the dip of the flexures of the coal beds is steep and at an average more than thirty degrees. Some flexures dip slightly near their outcrops with increasing dip towards the bottoms of the basins; others dip steeply on their outcrops and the incline decreases toward the depth. According to the present developments of the southern field, there seems to be little prospect of gently dipping bottoms in this coal field, but gently dipping flexures near the synclinal axis have been developed on the mammoth bed in the Shenandoah district, etc.

I must state here that only limited opportunities for the examination of the structural geology of the anthracite region have been offered to me because such investigations require time and money; they were principally confined to the southern field and a few collieries in the middle fields, but they were sufficient to enable me to outline a "sketch" of the structural and economical geology of the anthracite coal beds.

The synclinal of the mammoth bed in Kohinoor colliery consists of a number of rolls dipping about 8 to 15 degrees. From the bottom of the shaft toward the face of a gangway, then being robbed, numerous fractures of the coal bed of varying course and dip are visible on the ribs of the gangway. The thickness of the mammoth bed in the place of robbing and its neighborhood is stated to be about 50 feet. The average thickness of the mammoth bed in the Shenandoah district is stated by the second geological survey of Pennsylvania to be about 24 feet, but the same authority states also that the mammoth bed in many places is 60 feet thick. (Transactions of the American Institute of Mining E gineers).

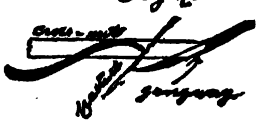
I maintain that a coal bed of an average thickness of about 24 feet cannot increase naturally to a thickness of 50 and 60 feet within such a comparatively small area as the Shenandoah

Fig. 6.



basin, and that such thicknesses as appear in Kohinoor colliery, etc., have been produced by longitudinal faulting, or over-lapping, as illustrated in fig. 6: *a*, represents the gangway; *b*, place being robbed; *c*, longitudinal fault, and *d*, the thickness, or over-lapping parts of the coal bed. The roof of the place being robbed was squeezy and alarming at the time of our visit, thus excluding a close investigation of the stratification; but the piles of rock, similar polished boulders, which had fallen down with the coal were convincing evidences to me that the abnormal thickness of the coal bed could have been produced by over-lapping only. In the same gangway there was exposed "a slickensides" with distinct striation, thus indicating beyond a doubt a gentle movement of the fractured strata. In another shaft of the same colliery a longitudinal fault had been developed with moderate dislocation on the "Holmes" bed as illustrated in Fig. 7. The character of the fault was so plain and distinct and in accordance with the established theories, that I desisted from further investigation of the rolls crossed by the continued cut.

Fig. 7.



In the mine "Hannibal" in Westphalia, there has been developed in a coal seam of six feet thick, longitudinal faulting with two fractures, thus increasing the thickness of the coal bed to about 15 feet for a distance of about 20 to 30 feet. The United States geological survey admits, that details of structure are duplicated in different districts. (Pamphlet "Coal" page 296, Washington 1887). In the coal mines of China, transverse faults have been developed similar to those faults developed in Europe and in the coal mines of Pennsylvania. (*Engineering and Mining Journal*). The application of the occurrence in Westphalia, mentioned above, to similar occurrences in the anthracite measures however, was rejected by a certain geologist, because the anthracite beds were not in Germany.

The southern anthracite field forms a narrow synclinal about 65 miles long and its topography is favorable to mining above water level; a facility which has been realized all over its

extent, especially in the Panther Creek region; either by adits on the coal beds or by cross-cuts. The Rhume Run cross-cut No. 1 in the Panther Creek region, was driven perhaps 50 years ago; numerous fractures of the strata were crossed and their disturbances of the coal beds (a great many of which are not accessible now), are in memory still through the name of a locality "Hell-Kitchen." There has been no distinct synclinal or anticlinal crossed by this cross-cut, notwithstanding the construction of three anticlinals and four synclinals by the second geological survey of Pennsylvania. The enormous disturbances of the strata in this cross-cut may be imagined from the fact that the strata of the tunnel mouth have been dislocated by a contrary dipping transverse fault, thus moving a great portion of the mountain towards the north for a considerable distance. Several miles west of this cross-cut there have been developed two longitudinal faults causing moderate dislocation, one of which is indicated on the maps of the second geological survey of Pennsylvania as an anticlinal turn, but this pretended anticlinal on the red ash coal bed was produced by faulting, and it has been explored successfully, according to the rules to recover the dislocated part of such a fault. The re-prospected part of the coal bed has been dislocated a second time by a fault in the same level, which I have defined to be a longitudinal fault and this exploitation, according to the rules, will prove successful also.

The numerous cross-cuts in this region have been and are still of enormous value for they have provided natural drainage, etc., and what is most important established the structural features of the coal beds, a knowledge of which is indispensable in laying out proper working plans; but they have also proven that the strata toward the synclinal axis (bottom of the basin) are enormously crushed and torn and there is no room for even a conception of the existence of the rolls constructed by the geological survey of Pennsylvania. The crushed condition of the strata for considerable distances north and south of the synclinal is overwhelmingly convincing, that the strata were hard at the time of the disturbance from their original horizontal position, and the illusion of the existence of "inversions" in the anthracite seams advocated by some mining engineers and imitated by the survey, is inexpli-

cable. A longitudinal fault of the mammoth bed, producing an over-lapping of the bed more than 2,000 feet long on the incline, was developed in Otto colliery about 40 years ago, and the relative position of the dislocated parts (about 1,300 feet horizontally), are explained to be on the contorted flexures of several anticlinal rolls and as many synclinal basins. (Report of the first geological survey of Pennsylvania, page 484.) Some mining experts have defined the phenomenon to be an inversion, while others hesitate to express an opinion. The fracture or fault crossed in a lower level is an irregular body of broken rock with a distinct stripe of disintegrated rock, and about 4 to 12 feet wide. The strata on the hanging wall of the fault lean with an anticlinal elbow, the part on the foot wall with a synclinal elbow upon the fault, and both flexures are regular with distinct lamination from one end of the cross-cut to the other. If this fault should be an inversion, then the so-called short leg of the inversion of the whole strata on top of the mammoth bed amounting to a thickness of 600–700 feet and including a number of workable coal beds, must have been compressed to a thickness of 4 to 12 feet, the width of the broken strata mentioned above. The impossibility of this needs no demonstration.

Several disturbances of the strata occur at Middle Creek colliery. They are partly developed and partly indicated. There are several adits on gentle north and south dipping flexures of the Buck Mountain coal bed as indicated in fig. 8. Within a short distance south of the adits, the Buck Mountain bed crops out more than 150 feet above those adit levels, showing an incline of about 40 degrees south. Such a sudden change of inclination within a comparatively short distance could not take place without dislocation, either by a contrary dipping transverse fault similar to that in Rhume Run cross-cut, or by a longitudinal fault; because the strata were hard at the time of the disturbance from their horizontal position. The existence of another more southerly longitudinal fault is indicated by two old slopes in an almost vertical plane within a short distance on the mammoth bed and confirmed in the lower workings. This phenomenon has been termed an inversion ever since.

Considerable disturbances of the strata by faults of both

characters have been crossed by the Williamstown tunnel. In the northern part of the tunnel for a distance of about 1,500 feet the strata are fractured and confusedly distorted, as in the Panther Creek region. The disturbances are not represented on the public maps (Report of Mine Inspectors), which indicates that no importance has been given to them, but their results will be developed very soon in the workings to be opened below the present deepest level and in the new shaft in Bear valley.

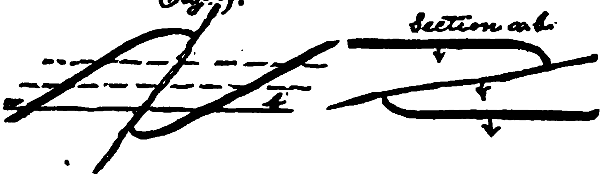
Longitudinal faulting has been met with in several other mines in the western portion of the southern coal field. There are also numerous lines of "shaftings," a great many of which have proven the existence of coal without contributing greatly to the knowledge of structural geology, but some of the lines indicate great disturbances of the strata.

One peculiar feature of longitudinal faults is that the flexures of the coal are contracted and bent more or less toward the fracture on the strike as well as on the dip, as illustrated in fig. 9, which might be explained as consequences of the prodigious oblique force of the sliding strata on the foot wall of the fault, the weight of over-lying measures and resistance of the under-lying strata. Horizontal sections, constructed in different elevations as indicated in fig. 9, always will show similar shapes. This feature is most distinct in the very hard strata of the anthracite region, but where softer measures are involved, the fracture is wide and represents a mass of broken strata similar to that exposed by the fault in Otto colliery and in a shaft in the Panther Creek region. It is obvious that longitudinal faults create a doubling of the strata of more or less extent, and it is therefore certain that many estimates of

the thicknesses of sedimentary rock will have to be subjected to corrections.

A glance at the maps of the western middle coal field of the second geological survey of Pennsylvania will convince one of the great number of anticlinal and synclinal folds similar to the one that occurs in the Panther Creek region, mentioned already. I maintain that perhaps with a few exceptions, they will be developed to be longitudinal faults, just as the occurrences in the Panther Creek region, etc., are. It is beyond doubt that longitudinal faulting is very frequent and predominant in the anthracite region, just as transverse faulting is predominant in the Pittsburgh region. As none of the existing faults are represented on the maps of the survey, it is obvious that they have not been recognized, and that therefore the contour lines on the maps, valuable as they otherwise might be, are illusive; because contour lines of the surface are the results of adequate surveys and underground contour

Fig. 9.



lines, especially in such a disturbed district, cannot be constructed beyond existing mine workings. That the faults of the anthracite measures have not been recognized by the geologists in charge, but rather the total absence of faults pronounced by them, is proven by a paper re-printed from the *Mining Herald.*

The industry of anthracite mining might properly be considered as the art of "controlling coal land companies," and "controlling mining companies."

The anthracite lands, to a great extent, were possessed by the Pennsylvania-German farmers and the excellence of anthracite as a domestic fuel and for manufacturing purposes in connection with the favorable topography induced them to make numerous openings in the ravines, etc. The construction of railroads and growing industries promoted increased demand for fuel and the organization of large coal land companies, thus

necessitating the employment of industrious surveyors and miners from abroad. The mining engineers of to-day as specialists, did not exist then, but many surveyors and miners became lessees of coal lands or took charge of operations, and in general they controlled all mining affairs.

At that time the science of structural geology and mining had not advanced to its present attitude in Europe; thus the new comers applied the theories of mining, etc., with which they were familiar, until financial and economical conditions necessitated the formation of gigantic mining corporations, which of course were obliged to put their interests in charge of those, liberated by the absorption of individual operators. It is natural that those commanding superintendents, etc., impressed their subordinates with their own theories, brought from abroad and improved by experience—they were the instructors of the present generation of mine officers, so to speak; and thus we find the science of structural geology of the anthracite region at the status of 50 years ago and still advocated by the mining engineers and geologists of this state. The results of such a state of affairs can be traced yet from the location of old mines and the business records of operators. It was natural therefore, that mining experts and geologists considered the southern field to be a deep synclinal with several rolls but without dislocation of the strata, and in their estimates they figured fabulous amounts of coal to be mined from this basin. A close investigation of railroad cuts, cross-cuts and tunnels in mines in the neighborhood of the synclinal axis will convince anyone that the flexures are enormously distorted. crushed and dislocated and that the estimates of available coal are vastly exaggerated.

The coal of the flexures in Sharp mountain, to a great extent, is destroyed and cannot be mined at present market prices. The coal seams of the northern flexure of the synclinal, especially the Mammoth bed, have been mined extensively toward the synclinal, whereby numerous dislocations of the coal beds have been met with (mentioned already) and a number of collieries have been abandoned temporarily, partly on account of the condition of the coal beds, and partly, because the present market price does not warrant a successful operation by inadequate improvements, (slopes, etc.)

In the western middle coal field, about 50 per cent. of the shipments are mined from other coal beds of the series and the rest from the Mammoth bed; and since the exhaustion of the thinner coal beds will progress rapidly, if the natural growing demand of coal shall be accompanied by an increased output, the only alternative which remains is to work the series of the smaller beds in the southern field too.

Economical geology is based partly on the structural geology of mineral deposits because every disturbance of the deposit influences, more or less, either the quality or quantity of the product, or the expense of mining. The numerous small disturbances of the Pittsburgh coal bed influence only the cost of mining in a very minor degree. The disturbances in the anthracite beds influence quantity and expense of mining, both disadvantages increasing considerably, especially by dislocations of great extent.

As the outcrops of workable coal beds have been exhausted extensively toward the synclinal, mostly by slopes; as the numerous flexures of rolls and dislocated parts of the coal beds should be worked economically by shafts and crossings of the strata in different levels; as such plants are exceptions in the southern field; as the expenses of mining increase downward in geometrical progression, in the face of an inexhaustible supply of cheap bituminous coal in western Pennsylvania, etc., rigid economy will be forced upon the operators in the southern field at no distant day, and the principal remedy, it seems to me, will be the study, now almost totally neglected, of the structural geology of the anthracite measures of Pennsylvania.

4128 Elm Avenue, Philadelphia, Pa., March, 1888.

THE ORIGINAL CHAZY ROCKS.

By Pres. Ezra Brainerd and Prof. H. M. Seely.

The extent and importance of the Chazy formation in eastern North America appears to have been under-rated. Prof. Dana, in his Manual of Geology (III ed. p. 184) states that "the thickness in some parts of New York is 100 to 150 feet." But in Chazy village careful measurements show a thickness of over 700 feet. The several varieties of these

limestones are well marked by their lithological characters and by their fossils; and some of them appear eastward in western Vermont in even greater force than at Chazy.

The economical importance of these rocks was shown by the discovery, about twelve years ago, of Chazy fossils in West Rutland, Vt., proving that the famous white and blue marbles of this region belong, at least in part, to this formation. But other beautiful marbles are also Chazy; "the Lepanto," a variety with reddish spots, quarried south of Plattsburg, N. Y., the "French Grey," from Isle la Motte, and the black marble so generally used for tiling, come from various strata of this formation. Large quantities of the purest lime are made from this rock in various towns of western Vermont—Swanton, Winooski and Whiting. Its massive beds have also furnished for many years excellent building material for forts, bridges and locks of canals.

As preliminary to a study of this formation in western Vermont, we present in this article a detailed account of its appearance in Chazy, N. Y., where it was first named and studied by professors Hall and Emmons nearly fifty years ago. For convenience of reference and for a better understanding of the accompanying map, we give below in a condensed tabular form, the results of our measurements.

Measurements at Chazy in Ascending Order.

Group A.

		Feet
1.	Iron-grey, fine grained dolomitic limestone, in beds one or two feet in thickness, weathering drab with fine yellowish streaks at right angles to plane of bedding; containing *Orthis costalis* and crinoidal fragments	110
2.	Tolerably fine limestone, filled with fragments of crinoids, containing *Orthis* and *Strophomena*	20
3.	Measures concealed	40
4.	Impure limestone, filled at bottom with *Orthis*, thin-bedded when long exposed to weather, the upper six feet abounding in crinoidal fragments	30
5.	Fine grained, massive limestone containing *Scalites angulatus*, *Raphistoma* and fragments of trilobites	25
6.	Impure limestone, abounding in *Orthis*	10
7.	Measures concealed	25
8.	Massive, grey limestone, largely made up of crinoidal remains, having red spots in a stratum about 10 feet from the top; abounding near the middle of the strata with gasteropods. *Bellerophon*, *Raphistoma*, *Metoptoma*, *Asaphus marginalis*, *Stenopora fibrosa*, *Bolboporites americanus*, *Retepora gracilis*	50
		310

Group B.

1.	Thick bedded, nodular, dark colored limestone, containing *Maclurea magna*	50
2.	Massive, pure limestone, grey, fine grained, often oölitic, abounding in crinoidal remains and *Stenopora fibrosa*	20
3.	Massive, bluish black, tolerably pure, nodular limestone, containing *Maclurea magna* and masses of black chert	45

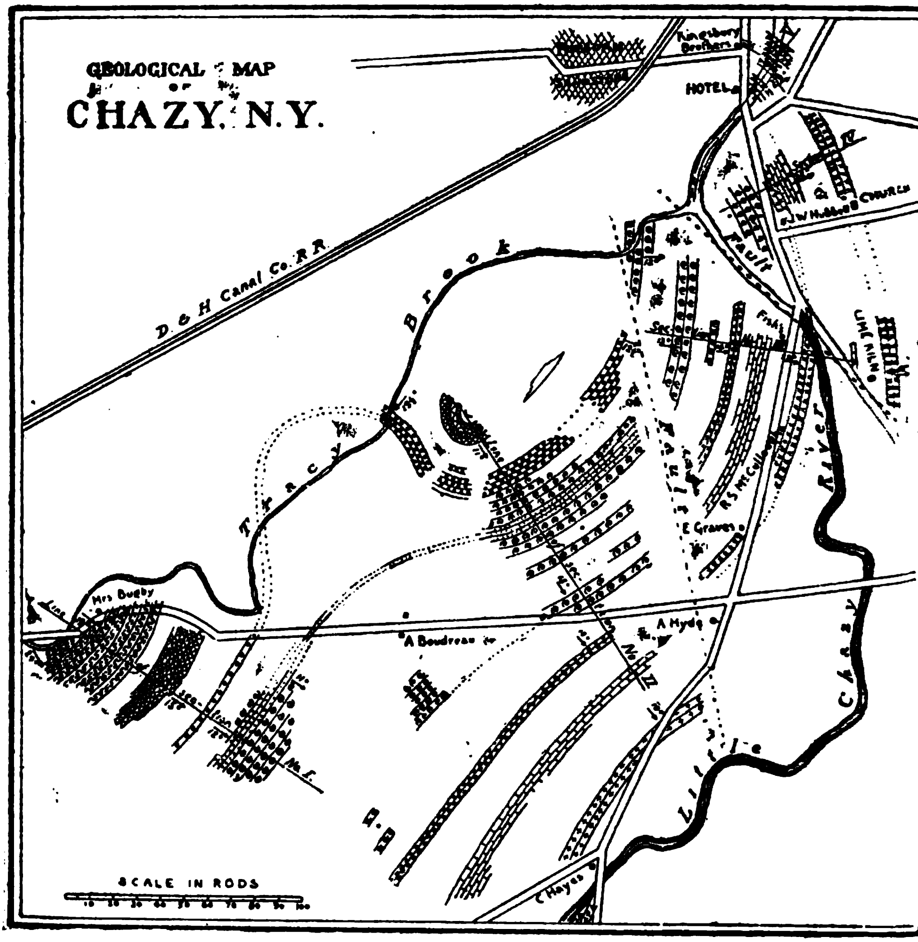
4.	Similar to No. 3, but containing in addition to *Maclurea*, various species of *Orthoceras* and large masses of *Stromatocerium*	90
5.	Less massive limestones, quite impure and often disintegrating into nodules as though shaly	60
		265

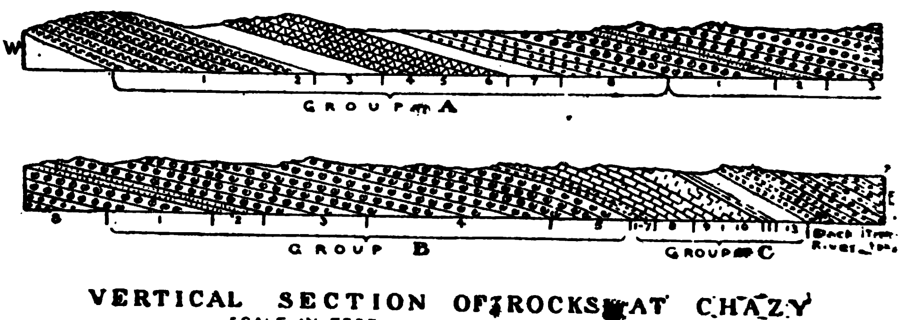
Group C.

1.	Dark, iron-grey, dolomite, weathering yellowish	1
2.	Blue, compact, fine grained, pure, limestone, containing fine lines of calcite.	6
3.	Dove colored, compact, brittle, perfectly pure limestone containing small nodules of calcite	5
4.	Iron-grey dolomite	8½
5.	Like No. 3, only containing larger nodules of calcspar	4½
6.	Dark grey, fine grained compact limestone somewhat impure, having a mottled aspect when weathered, containing several undetermined species of *Murchisonia Orthoceras* and usually enveloped in Strephochtus	2
7.	Iron-grey dolomite	1
8.	Blackish, impure limestone, abounding in *Rhynchonella plena*	36½
9.	Dark or light grey, massive coarsely granular limestone, mostly made up of crinoidal fragments which are sometimes red, containing *Rhynchonella*	26½
10.	Same as No. 8	32
11.	Measures concealed	7
12.	Tough, impure dolomite	8
13.	Concealed	24
		157
	Total thickness of A. B. and C	732 ft.

The map covers a tract of nearly 1½ square miles, including the village and the farming land for a mile to the south-west. Through this region the rocks crop out, in hundreds of places, though more covered by soil than the map might lead one to suppose. The ledges dip in various directions, and the explorer who runs over them for the first time is greatly perplexed to make out the stratigraphy. Notwithstanding the even and regular appearance of most of the exposures, the region has evidently been one of great disturbance though without any traces of the metamorphism due to heat. Two great faults run obliquely across the measures; one, from near the mouth of Tracy brook, south-easterly along the bed of the Little Chazy river for forty rods, and on past the south end of the ledge of Black River limestone; the other, crossing Tracy brook about thirty-five rods farther west, and running nearly due south by the compass through a point just west of Mr. Hyde's house. These two faults divide the tract into three areas which for the sake of distinction we shall call the western, central and north-eastern areas.

There is evidence of further dislocation on the south. The ledge of Black River limestone south of Mr. Hayes' house between the highway and the river dips south 52 degrees east, at an angle of only 5 degrees, and lies too far to the east to be con-





VERTICAL SECTION OF ROCKS AT CHAZY
SCALE IN FEET

Note.—The shading in the map corresponds to that of the vertical sections.

tinuous with the same strata seen to the north. The long outcrop of dove-colored limestone at the base of Group C. suddenly terminates at the south and is succeeded in the line of strike, after a short interval, by massive ledges of lower strata containing *Maclurea magna.*

On the north side of this western area are indications of still profounder disturbance. The rapid curvature in the strike of the Scalites beds (Group A. 5), their abrupt termination to the north-east, the presence still farther north-east of a large mass (indicated on the map without shading) of the crinoidal beds (Group A. 8), the existence of large irregular outcrops of Black River limestone between the brook and the railroad,—all indicate that we are approaching the axis of greatest dislocation.

If we look a little further north we find a low hill of Potsdam sandstone, around the south-east side of which the railway curves. Only forty rods to the east near the house of Kingsbury brothers is an outcrop of the Black River limestone, which, if it continued in the line of its strike, would come in contact with the sandstone. Eighty rods to the north-west of Mrs. Bugby's the railroad cuts through another exposure of the Potsdam sandstone, the apparent center around which curve the ledges of the lower Chazy, (Group A.) south-east of Mrs. Bugby's. The strata of sandstone are nearly horizontal and stretch to the westward for fifteen or twenty miles. They are covered with but little soil and few trees, and form a desolate region known as the "Flat Rock," useful chiefly for its enormous crops of blueberries.

It is a noteworthy fact that the rocks of the Calciferous formation which in Beekmantown, eight miles south, show a thickness of 300 or 400 feet, do not anywhere appear near Chazy village between the Potsdam Formation and the Chazy. Mr. Charles D. Walcott (U. S. Geolog. Surv. Bull. No. 30, p. 22) thinks this an instance of non-deposition due to elevation of the sea-bed in this region while the Calciferous deposits were taking place. But the non-appearance of Calciferous rock may be the result of a fault along a line between the railroad and Tracy brook, raising the rock on the north-west a thousand feet higher than on the south-east and producing the marked disturbances in the Chazy rocks under investigation. Just such a longitudinal fault appears on the east side of Isle la Motte,

six miles distant, where Chazy limestone on the west is in juxtaposition with Utica Slate on the east.

THE STRATA OF GROUP A.

The lowest group of Chazy rocks as above described, were placed in the Calciferous formation by Prof. Emmons, and the exposure along section I is the one referred to in the N. Y. Geology of 2nd Dist., p. 311. Prof. Hall, however, in his N. Y. Paleontology, published four years later, in 1846, describes the fossils of these strata as belonging to the lower part of Chazy. The lowest strata (A. 1 and 2) are seen only along section I, forming south of Mrs Bugby's house a ledge twenty or thirty feet in hight partially covered with soil.

After going south-easterly across a low valley, where the soil conceals about forty feet of the rock, we reach a second ledge in which 4, 5 and 6 of Group A are well exposed. Especially favorable for study are the Orthis beds on the east slope of the ledge, where the rock has been quarried for railroad abutments. The strata may also be studied to advantage at the north end of section II where they form a ledge somewhat wooded, over thirty feet in hight, with abrupt, broken edges on the north-east and an even slope with the bedding to the west and south. We found this an excellent locality for *Scalites angulatus*, which is rarely obtained except in weathered sections.

After another unavoidable hiatus of twenty feet, we reach the crinoidal beds, (A. 8.) These are best seen along section II following the curving strike either to the east or the west. The stratum with red spots has furnished a beautiful and valuable marble. The Burlington Manufacturing Co. sell it extensively for furniture and indoor work. It has been quarried somewhat where the Tracy brook runs over its beds, as shown in the map. At least two other quarries have been opened between Chazy and Plattsburgh. It has also been quarried on the west shore of Isle la Motte just south of Fisk's Landing.

THE STRATA OF GROUP B.

The middle group consists largely of the well known massive beds of limestones, easily recognized wherever found by the spiral seal of *Maclurea magna* stamped upon its weathered surfaces. Along section II the lower bed of fifty feet in thickness is to be seen, resting upon the crinoidal beds below,

and in contact with the oölitic beds above. It appears also at the base of the wooded ledge on section I.

The oölitic beds (Group B. 2,) are twenty feet in thickness, and never contain *Maclurea magna*, so common in strata both below and above. The weathered surface is covered with minute grains, like the roe of fish. No organic structure has ever been made out; but the mechanical origin of such concretions remains unexplained. This rock is a quite pure limestone, firm and fine-grained, and is extensively quarried in Isle la Motte as a marble. Polished specimens are beautiful, showing the outlines of crinoidal fragments. It is known in trade as "French Grey."

The upper Maclurea beds have a thickness of nearly 200 feet. They are best exposed at Chazy in the central area, though they crop out at various points in the western area, as indicated on the map. The strata just above the oölitic beds furnish an excellent black marble, though at Chazy they have been quarried only for building stone, where they are crossed by the Tracy brook.

Farther south-east in the pasture of Mr. Fisk is a bold black ledge (Group B, 4) covered on its eastern slope with embedded fossils of great Maclureas; while just beneath is a stratum containing masses of Stromatocerium two or three feet in diameter. This is known by the quarrymen as "curls," and is considered a blemish in the stone when used as floor tiles; though the graceful coil of the Maclurea is tolerated, and is often seen under foot in the corridors of our public buildings. The upper beds of Group B contain more or less earthy matter, and the rock has a mottled appearance after a few years exposure; and in ledges that have been long exposed, it often disintegrates into nodules an inch or two in diameter.

The Strata of Group C.

The upper group is as remarkable for its great variety and sudden transitions as the middle group is for its uniformity. It was all classed by Emmons with the Birdseye formation, to which some of the lower strata bear a marked lithological resemblance, the lines of calcspar having been erroneously identified with the *Phytopsis tubulosum* of the Mohawk valley. The first twenty-three feet consist of repeated alternations of tough siliceous dolomite, and brittle pure limestone. It is well

exposed in each of the three areas. Just east of the street along section IV. all the strata are to be seen, although in a limited area. Forty rods farther south on the north-east bank of the river, they are found resting on the mottled rocks of Group B, 5. But half a mile farther south they appear in a long ridge with beautiful sections of Murchisonia and Orthoceras weathered on the surface. There is reason to suspect that rocks of this horizon occur in even greater force along the eastern shores of lake Champlain, and they remind one of similar strata described by Sir Wm. Logan as occurring at the Mingan island. (See Geology of Canada, p. 135.)

Along section IV, in the village of Chazy, overlying the one foot stratum of tough dolomite, (C, 7) are to be seen the lower beds of Rhynchonella, above thirty-six feet in thickness. These pass into lighter colored and more massive beds of purer limestone, which appear just north of a large barn, in a low ledge sloping eastward into the soil of a garden, that conceals all the higher strata of Group C. But in the bed of the Chazy River, forty rods to the north just under the dam, the light-grey strata again appear, and are succeeded by other strata of Rhynchonella at least thirty-two feet in thickness. These three measures, amounting in all to ninety-five feet, should be classed together, the difference resulting chiefly from the greater or less degree of earthy matter in the matrix surrounding the shells. The shells themselves contain pure calcspar, and occasionally small crystals of quartz; though some are partly hollow, like miniature geodes. These strata crop out in the central and western areas, usually in rounded ledges, the rock often disintegrating after long exposure. We may here note that the thickness of the Rhynchonella beds in Grande Isle Co., Vt., were found to be seventy-one feet.

There yet remain about forty feet of rock before we reach the lowest observed strata of the Black River or Birdseye formation. Unfortunately this is everywhere concealed by the soil, excepting about eight feet which are scantily exposed in the bed of the river. This is a tough, black dolomitic rock. The horizon, however, is one of special interest, corresponding to the strata of Fort Cassin, Vt., in which in 1886 over thirty new species were discovered. (See Bull. Am. Museum of Nat. History, vol. 1, No. 8.)

Middlebury College.

POCKETS CONTAINING FIRE-CLAY AND CARBONACEOUS MATERIALS IN THE NIAGARA LIMESTONE AT CLINTON, IOWA.

By P. J. Farnsworth.

In the first volume of the geological reports of Iowa, 1854, an account is given of certain caves or openings in strata of the age of the Niagara and Devonian limestones filled with what is supposed to be the under-clay of the coal formation. One described and figured is in the quarry near Rock Island. Such cavities are numerous in the lower part of the Niagara, about Clinton, and are also mentioned as occurring in the Galena in the lead mining country about Dubuque and Galena. There is also one figured and described in the Devonian near Iowa City.

The one described in the quarry at Rock Island answers to several that I have examined in the vicinity of Clinton. "The surface of the rock beneath the superincumbent soil presents a depression which deepens into a broad funnel-shaped cavity, gradually narrowing below till within ten feet of the bottom, when it spreads out on one side with an irregularly arching roof and an unequal floor. It is filled from top to bottom with hard clay, similar to the under-clay of the coal seams. * * The laminations of this clay conform to the curvatures and irregularities of the roof and floor of the ancient cavern and exhibit the appearance of having flowed in while in a semi-fluid condition, while the hydrostatic pressure of the mass above, acting through the deep funnel had forced the soft mass against the walls and roof of the cavity, causing it to assume in its lamination the same contour."

"In the midst of this clay was the impression of a large *Euomphalus* very similar to a carboniferous form, * * with this exception, no fossils were observed in the clay of this locality."

"In a section near Iowa City in a cliff of limestone of the Hamilton group between beds of a nearly horizontal limestone, appears a black band extending thirty or forty feet; this consists of black carbonaceous mud, the upper part having the character of cannel coal, and the lower part a slaty carbonaceous shale. Beneath this and less extended a thicker layer of

clay precisely like that found in the cavities before described, and of the character of under-clay, fills the upper and broader part of the cavity; while below this and occupying the deepest parts is a coarse sandstone which follows in its lines of laminations the curvatures of the limestone upon which it lies. In the slaty portion have been found *fish teeth* of Carboniferous character."

These descriptions would apply to cavities examined in the Niagara limestone at Clinton in almost every particular. Some facts must have escaped the first observers. In a quarry in the bluff near the river is a fine exposure of one of these cavities or fissures,extending for a distance of two hundred feet, and having a depth of from twenty to thirty feet and an irregular width of from five to ten feet. The top of the bluff was covered with four or five feet of loess or modified drift; then occurs what was once an opening not more than six feet in diameter, though it might have been longer. The cavity was filled to the depth of ten feet with a ferruginous sand, differing from the drift in color and composition; then a reddish arenaceous clay; then the cavity broadened out in every direction into a long cave which was filled with laminated clay, conforming to all of the inequalities and sinuosities of the cavity.

At a depth of ten or twelve feet from the opening appeared carbonaceous mud similar to that spoken of as being found at Iowa City, these bands of carbonaceous clay or black lines in the clay extending down for a foot or more. In the lower levels of the cavern the clay completely filled the opening and no black bands appeared, but above that it was seen uniformly. No trace of fossils has been found in the clay, but in the carbonaceous band pieces of pyritized wood and pieces resembling bark were taken out, resembling exogenous growth. The clay is of soft consistency and grayish color, burning nearly white, or the color of pottery clay. In fact a large portion of it was used in a pottery factory while some was used for fire-clay around the engines of the saw-mills. The carbonaceous band burns away leaving a trace of oxide of iron. The grayish clay yields no effervescence with acids and no trace of iron when heated. In other places are found similar cavities having no trace of the carbonaceous material, some of them containing a considerable amount of white sand.

In excavating a pit for the Clinton water-works an extensive pocket of this clay was met with. The site is on the bank of the Mississippi river sixteen feet above low water and two feet or more below extreme high water. It is at least fifty feet below the level of the bluff where the first described deposit occurs and probably ten feet lower than the lowest part of that cavity. In this for two or three feet below the surface were the regular horizontal black bands, then the grayish clay extending to the bottom of the pit forty feet.

The theory advanced by Prof. Whitney is that there were "ancient enlarged fissures and cavernous openings made by running water and afterwards filled with clay during the deposition of the 'coal measures.'"

This seems probable except as to the age to which it is ascribed. The uniform character of the clay with its upper bands or mixture of carbonaceous materials occurring in the different levels of the Niagara, under the modified drift of the river bluff, or in the valley of the river, points to a deposit after the denudation that had left the region in its present surface condition. The flood plain of the Mississippi at Clinton is of post-glacial age, the valley not far away having deposits of peat and forest beds containing wood and bark of pine and cedar trees. It would seem that these cavities were filled with a deposit of fire-clay and carbonaceous material at the bottom of some deep still water or in a sluggish current, and one of these at least was filled after the river channel had been cut to nearly its present level.

Between the Niagara formation and the Galena or Trenton the Hudson River holds a thick bed of shale that weathers to a clay very similar to that found in the cavities. This has been denuded from the upper part of Iowa and of Illinois. An exposure of this formation easily disintegrates into fine clay, and might have been transported in a sluggish current, while with it might have come carbonaceous material from some older peat formation.

Prof. White, in his report of the geology of Iowa, page 119, gives an account, with a drawing, of a cutting of the C., R. I. & P. R. R., at Davenport, where under twenty-five feet more of soil and yellow clay, a bed of brown peat occurs one foot thick. Beneath it is what may be the boulder clay, the deposit being

140 feet above present low water mark in the river. This and another deposit he says has been referred to the Terrace epoch. There may be no connection between this and the fissure deposit in the rocks across the river and elsewhere, but the carbonaceous material seems similar. I have found no mention of these cavities or fissures in the Illinois reports though they are known to exist in quarries in Whiteside county and among the lead mines about Galena, and may occur elsewhere.

NOTE.—In the second annual report of the Minnesota survey, 1873, are described several pockets and cavities excavated in the Silurian limestone at Mankato, Minn., filled with what was taken to be Cretaceous clay. Since then the Cretaceous has been found filling cavities and fissures in the Devonian at Austin in Mower county, and at LeRoy in the south-eastern part of the same county near the Iowa state line. Cretaceous deposits, *in situ*, have been found widely distributed in the southern part of the state. They contain fossil leaves that are referred by Dr. Lesquereux to the Dakota group. In a similar manner Cretaceous deposits are described as filling gorges in the older rocks in Missouri and in Southern Illinois. Circumstances point to the Cretaceous as the probable age of the clay above described by Mr. Farnsworth. The fish teeth, the carbonaceous matter, the white sand (same as at Austin) the fossil wood, the fire-clay quality, are all characters that appertain to the Cretaceous in Minnesota. A microscopic examination might reveal characteristic foraminifera.

N. H. W.

EDITORIAL COMMENT.

FORMATION OF COAL SEAMS.

W. S. Gresley, Esq., F. G. S., publishes in the Quarterly Journal of the Geological Society for November, 1887, a paper in which he attacks the "growth-*in-situ* theory" of the formation of coal. He says that the advocates of that theory adhere to it because, (1) "the accumulation of the vegetable matter of coal beds by driftage appears to be totally beyond our comprehension, (2) we have been told and led to believe that the underclays of the coal seams contain the *Stigmariae* which were the very roots of the trees, the remains of which constitute the bulk of the coal."

If it be true that we must accept either growth *in situ* or driftage, with no possible third alternative, then the first of

the above reasons will bind us forever to the first theory. Not only is it a good reason in itself, at least to the extent of excluding driftage as a valid explanation, but Gresley himself makes no attempt to render comprehensible that which "appears to be totally beyond our comprehension." Until some one can show us, in estuary or delta somewhere, a raft of vegetation accumulated by drifting which is pure enough to form a good seam of coal, we need not strain our faculties in the attempt to comprehend how it could get there in such a state of purity and freedom from intermixture with earthy sediments.

Gresley states that his "principal object is to bring forward evidence in opposition to the view now generally accepted that coal seams are formed from vegetation which grew on the spot;" yet he hesitates, or appears to hesitate, about adopting the driftage theory. What would he have? Is there a third alternative? He says in conclusion that "what evidence we do possess decidedly favors a drift or at all events an aqueous origin." Whatever he means by "aqueous origin" makes all the difference between his theory and that of growth *in situ*. When he shall tell us more clearly just what he means we shall probably find no difficulty in agreeing with him, for the general belief is that coal is of aqueous, *i. e.*, *swamp* origin.

The meaning of "growth *in situ*" perhaps needs explanation also. Gresley interprets it with literal exactness, as if each cubic foot of coal was produced upon that identical square foot of surface. The body of his paper is devoted to disproving the proposition that coal plants grew from the underclay up through the coal seam and thus produced the latter! Some careless reader of carelessly written elementary text-books may entertain such a notion, but no practical geologist ever did. What is meant by growth *in situ* as opposed to driftage may be illustrated by the actual conditions in existing swamps. The products of vegetable growth, leaves, twigs, spores, pollen, &c., not only fall where they grew but are carried by winds over the adjacent lagoons where nothing grows. Lesquereux found the bottom of Drummond lake, in the Dismal swamp, covered with the same layer of vegetable matter which fills the surrounding swamp. So the open lagoons of swamps in the Carboniferous age received their share of vegetable debris, and

each square rod of the swamp both gave to and received from the surrounding areas a portion of their accumulations.

Sluggish currents within the swamp may sometimes have aided in the distribution of the vegetable matter. But the moment such currents became extensive and powerful enough to justify the term driftage, then silt would accompany the organic matter, and bone coal, bituminous shales, or sandstone with coaly streaks and rolled fragments, would be deposited.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Die carbone Eiszeit. PROF. DR. W. WAAGEN. *Jarhbuch d. k. k. geol. Reichsanstalt. Vol. xxxvii, H'ft 2, pp. 143-192. Wien, 1888.*

The question of a glacial epoch in Paleozoic time is one involving some of the most interesting and puzzling problems that have been under the consideration of geologists and paleontologists during the last two decades. The scene of the most active scientific dispute is laid in the southern part of the eastern hemisphere where the coal-fields of India, Australia, and Africa present a rich conservation of organic remains indicating an age that is almost directly at variance with its purely geologic probabilities.

In India we have the well-known conflict between a stratigraphy that is Carboniferous, a fauna that is Lower Mesozoic, and a flora that is chiefly Middle Jurassic in its affinities. Dr. Waagen in this interesting contribution, employs chiefly the evidence furnished by the two extremes of the controversy, stratigraphy and paleobotany. Beginning with the stratigraphy, he refers to the results obtained by Blanford, Thomas Oldham, and Fedden, showing, in the presence of striations, furrows and conglomerates, indications of glaciation in the lower strata of the Godavery valley and the Talchir group; he points out similar phenomena as made known by Sutherland and Griesbach in southern Africa, and the admitted glacial agency attending the formation of the Baccus Marsh sandstone, as probably also that of the Hawksbury terrane in Australia. In these continents the glacial formations occur among beds of coal or sandstone containing a rich flora.

The widest variation of species occurs in the coal strata of India, the lower horizons of which contain well recognized species, such as those of Merianopteris, characteristic of the upper Carboniferous; or, in higher strata, the Voltzia heterophylla, and Triassic species of Neuropteris and Sebertia, and so passing upward through a flora of higher affinities, such as Glossopteris, Phyllotheca, Vertebraria, and Schizoneura, until the greater number of species have their nearest relations in the Rhetic, Lias, and Oolite of the more northern countries. It will be remembered that the Indian flora, especially that of the Damuda group, is very similar to that

of East Australia, Gaugamopteris cyclopteroides, which is so widely distributed in India, being common to both continents.*

In South Africa the central sandstone formation, which extends over the northern part of Cape Colony, over Orange Free State, Natal, Transvaal, and the desert lying westward, rests unconformably, in part, on the Devonian, but chiefly on the celebrated Table Mountain sandstone which, in turn, rests conformably on the Devonian or unconformably on the Silurian, and which contains coal with remains of Lepidodendron and Calamites.

The lower member of the overlying Karoo system is the Ecca shale, containing marine fossils. Above this follows the Ecca-conglomerate, so long regarded as eruptive, but whose glacial origin was first suggested by Dr. Sutherland. This formation, over 1,200 feet in thickness, consists of a grayish-blue, clayey matrix containing fragments of Quartzite, Granite, Gneiss, Greenstone, and clay shale, varying in size from pebbles to ten tons in weight. It rests usually unconformably on the Table Mountain sandstone whose contact surface is eroded with deep furrows and scratches, as if by the passage of a half plastic substance in which were embedded hard, angular fragments, such, in fact, as correspond exactly to known glacial action. An upper clay shale, of considerable thickness, follows which contains sandstone and coal in places, with occasional plants; although thus far only a a species of Glossopteris has been described. Following are the Koonap and the Beaufort strata containing vertebrate remains and plant impressions among which Tate has described five species of Glossopteris and one of Phyllotheca. The Stromberg strata are most nearly allied in vegetable and animal remains to the Rajmahal and Jubalpur strata of India, the plant genera being included in those of the latter formation. Ascending to the Uitenhage group a more complete paleontologic transition to the Middle Jurassic takes place, the vegetable and animal remains corresponding with a surprising degree of coincidence with those of the upper formation at Cutch in the Oomia strata. Two species of plants are identical with those of the Rajmahal, while other genera are common to the Scarborough Oolite.

In eastern Australia, so far as known, the situation is similar to that of south Africa, a Devonian formation with Lepidodendron and Cyclostigma sp., above which occur the Carboniferous strata of the Muree formation. The latter at Stroud Arowa, Port Stephens, and Smiths creek, contain in their lower strata remains of Calamites radiatus Brougn, Lepidodendron reltheimianum and Volkmannia, along with other true Carboniferous fossils. The strata above, however, contain delicate corals and marine animals of Carboniferous affinities associated with plants, among which are Phyllotheca sp. and five species of Glossopteris, belonging chiefly to the Mesozoic. This part of the formation consists of a matrix of fine sand or shale in which are implanted pebbles and boulders of crystalline and other rocks, attended by all the characteristic phenomena of deposition from icebergs. The marine animal remains are undisturbed in their original habitat.

* Unfortunately it is impossible to reproduce here the synopsis of the floras of th different continents and horizons.

Superimposed on these are the New Castle strata and the Hawksbury formation corresponding almost specifically in organic remains to the Karharbari and Damuda of India respectively. The Hawksbury terrane shows again a return of glacial action, though in a less marked degree. Above these coal formations with signs of denudation, rests, with slight unconformity, the Wianamatta terrane consisting of dry shales and fine sandstones. Nearly the same geological features may be seen in Victoria as in New South Wales. It is impossible to repeat Dr. Waagen's array of facts and evidences, but the synopsis of his geologic results, from both sorts of evidence, in India, Africa and Australia, may be seen in the following table:

	SOUTH AFRICA.	INDIA.	EAST AUSTRALIA.
Neocomian, Tithon.	Uitenhage ?	Cutch {Plant Strata, Marine Tithon.	?Marine strata in Queensland.
?Rhetic and Jurassic.	Stromberg.	Jabalpu, Kota-Maleri, Rajmahal.	Bellarine strata, Clarence river, Coals of S. Queensland
(?)Triassic (?Lowest.)	Beaufort.	Panchet Group.	Wianamatta Unconformity.
Permian.	Koonap.	Damuda Series.	Hawksbury, (Glacial.)
Upper Carboniferous.	Unconformity.	Karharbari.	New Castle.
	Ecca Strata. (Glacial.)	Talchir Group. (Glacial.)	Stony creek, Baccus Marsh, (Glacial.)
Lower Carboniferous.	Lepidodendron Sandstone.	Unconformable on Crystalline Rock.	Stroud, Port Stephens, etc.
			Lepidodendron Sand.
Devonian.	Marine Devonian.		Marine Devonian.

In the Uitenhage and Cutch formations, as well as to some extent in the Muree, the animal remains indicate a Neocomian age, while the plants are clearly oolitic in their relations. This contradiction between animal and plant remains is one between organisms closely intermingled and in their natural habitat. The plant remains indicate distinctly a Mesozoic age generally for the coal bearing strata, hence it is probable that in Australia the Paleozoic animal forms lived longer than in Europe, extending even into the Mesozoic epoch. In support of this the abundance of the older types of the fauna in Australia descending from earlier periods may be cited. There, also, in geologic time the older types may have extended higher than elsewhere. The question of the age of these strata is now, however, of more special interest on account of the glacial

formations which are met with in the same horizons. The probability of the Permian age of these formations has been made far more certain by the recent contributions to this subject from the discoveries in the salt range which put the question in a new light.

In the salt range the glacial evidences of the "Olive Group" have long been known. Transported glacial boulders of an older Paleozoic age are embedded in a formation that underlies the Permian. It has also been noticed that no post-Carboniferous remains are found in this glacial formation which contains nodules with organic remains, nearly half of whose species are identical with those of the Australian coal measures.

While utilizing the data obtained by Oldham and Wynne, Dr. Waagen, shows that the glacial indications observed by them at various localities, all belong to the same formation instead of different ones, as they supposed. There can be almost no doubt, then, according to all the rules of synchronism, that the glacial formations of the salt range are to be regarded as of the same age as those of Australia, whose fauna are so largely identical. In Australia we have the lower Carboniferous beneath; in the salt range are unquestionable Permian strata above. With regard to the change in plant life at the appearance of this glacial epoch, it was natural that the older true Paleozoic species such as those Calamites and Lepidodendron should hardly survive so great a change of temperature.

In the increasing coldness which the glacial advance brought on, the older and more delicate types were forced to give way and only the hardier forms and such variations as were developed amid, and enabled to survive the exigencies of a gradually changing climate, remained to form the nucleus of rich Mesozoic flora which followed. A further conclusion which the author derives is that the Mesozoic plant types which originated in the Carboniferous epoch on this great southern Africo-Indo-Australian continent are *autochthonous* t here and that the European Mesozoic flora which possesses so great a similarity is to be regarded as descending from this Paleozoic flora which at the time of the coal-measures gave it origin in the southern continent. The great factor is glaciation which the author supposes to have extended from about 40° south latitude to 35° north, and from 35° east to 170° east from Feno, an area which included more than one-fourth of the earth's surface.

With regard to the claims for a Paleozoic glacial epoch in Europe the author gives a comprehensive discussion. Though, contrary to the opinions of Geike, he doubts the probability of a glacial origin for the conglomerates at the base of the Carboniferous in the south of Scotland; he regards the indications furnished in the Permian breccias of the British Isles, especially the midland counties of England, the conglomerates of the Upper Carboniferous in France as well as the more important evidences in the Silesian coal-fields, the Alps of the Gail, and various other areas of Europe, as demonstrating almost beyond doubt the occurrence of glaciation in the upper division of the Permian. A fact of the greatest importance is the transition from the Paleozoic to the Mesozoic floras accompanied by the extinction of the greater part of the Paleozoic types in the middle Permian, contemporaneously with the occurrence of the glacial phenomena,

as has been previously noticed in England. Throughout Europe the marked change of the flora goes hand in hand with the change of climatic relations. As to the evidences of such glaciation in North America, Dr. Waagen is not assured; though he maintains the probability of a great depression of temperature occurring in the Permian.

The glacial formations in the Hawksbury strata of Australia he regards as synchronous with the northern Permian glaciation and representing the diminished climatic severity and the recession of glaciation to the south. In India he finds no trace of Permian glaciation. The Permian fauna he considers to be not autochthonous, but of a composite origin, the greater part immigrating from China whither it had previously come from America at the age of the upper coal-measures. Another small tributary indicates a connection with the Carboniferous fauna of Australia which, being imbedded in the glacial strata, may be considered as cold water fauna; and from this it appears why so few types, so many representatives of which occur in the Salt Range, have survived in the Permian of India. A third very small tributary indicates, finally, an origin in the Caucasus.

In answer to the question why the glacial phenomena which destroyed Paleozoic plant types should not have had a similar effect upon the marine fauna and so caused the reduction of the Paleozoic animal types, Dr. Waagen cites the Quaternary glacial epoch, a study of whose marine fauna shows that the types are not destroyed but are preserved by a horizontal movement which thus adapts itself to the temperature relations. The author supposes that in the Salt Range of Australia the Carboniferous fauna which flourished richly in the warm currents from the east, was suddenly cut short at the end of the Permian by cold currents setting in from the north—an hypothesis that is corroborated by the affinities of the types. This influence existed throughout the whole Triassic and Jurassic periods, extending far southward to the borders of the Southern sea.

This great change in the sea fauna at the end of the Paleozoic time resulted directly or indirectly from the depressions in temperature which extended more or less rigorously over the whole earth with the exception, perhaps, of South America. The latter continent shows no authentic indications of glaciation either in Carboniferous or Permian time. During the Carboniferous glacial period that continent seems to have played a role similar to that of western North America in the Quarternary glacial epoch. In conclusion, the author regards it established beyond doubt that the glacial epoch, which extended during the Carboniferous period with very great influence over a continent which lay chiefly south of the equator, spread itself later in the Permian over a greater part of the earth's surface. Concerning the causes of this great temperature depression, the author can offer no explanation; but he points out as an incidental conclusion, that in the earlier as well as in the later periods, the distribution of plant types on the surface of the earth, as revealed in their fossil remains, should only within certain limits be employed as characteristic fossils by which to determine the age of the strata containing them.

Tables for the determination of common minerals, By PROF. W. O. CROSBY.

Second edition. T. Allen Crosby, Boston, 1888. These tables are especially adapted to the use of schools and private students and require but little chemical knowledge or apparatus. They have been designed to enable students to determine readily and accurately, by their more obvious physical and structural features, those minerals which they are most likely to meet. The method of the determinations is similar to that of analytical botany, and the author has aimed to show that common minerals can be determined with the same ease and accuracy as common plants. The tables are prefaced by an Introduction in which all the various properties of minerals and the simple tests required for their determination are fully explained. They are also accompanied by a synopsis of the classification of minerals, so arranged that when the student has determined a new mineral he may readily refer it to its proper place in the classification and thus learn its relations to other minerals.

Geology: Chemical, Physical and Stratigraphical. By JOSEPH PRESTWICH, F. R. S., Professor of Geology in the University of Oxford. In two volumes. Vol. I. Chemical and Physical, 1886. pp. XXIV and 477. Vol. II Stratigraphical and Physical, 1888, pp. XXVIII and 606. Royal 8 vo. Oxford, Clarendon Press.

British geological students are to be congratulated on the possession of two so comprehensive and thorough treatises as Archibald Geikie's *Text Book of Geology*, revised and enlarged in 1885, and the present work, the plan of which is best told by Professor Prestwich's preliminary remarks in his second volume.

"The subjects discussed in the First Volume of this work related to the composition of rocks and to the changes brought about in them by the action of the various meteorological agencies on the surface, and by thermal and chemical action at depths. In it also were described the nature of the disturbances which the rocks have undergone by the action of subterranean agencies,—the deformation of the Earth's Crust which has resulted therefrom,—the elevation of mountain chains,—and the manner of volcanic action.

"My object in this Volume is to enquire what possibly may have been the original condition of the Earth's Crust,—to note when Life first made its appearance upon it,—to determine the character of that Life, and to follow its development and successive modifications through all Geological Time. *Pari passu* with the Biological Evolution, the great physical changes of the surface, the constant alteration in the distribution of land and water, and the relation of these physiographical changes to the distribution of life on the land and in the waters, are briefly noticed."

The frontispiece of volume I is a geological map of the world, on Mercator's projection, reduced from the large map of Prof. Jules Marcou. This volume also contains two other maps of the world on the same scale; —one showing the distribution of active and recently extinct volcanoes, and of the areas affected by earthquake shocks, with approximate contours of ocean depths at intervals of 1,000 fathoms;—and another showing the distribution of the coral islands and great coral reefs and the areas of elevation and subsidence within the modern period, together with the

principal ocean currents and isothermal lines of January and July and the mean annual line of 32 degrees Fahrenheit in both hemispheres. There are also three plates of sections:—1. Illustrating the action of springs and underground waters (several sections in England). 2. Coal fields of Somerset and Bristol, of Liege, and of Westphalia. 3. The Mount St. Gothard tunnel, part of the northern flanks of the Alps, and across the Alps from the neighborhood of Zurich to near Como, 180 miles. Two chapters, pp. 308–359 are devoted to metalliferous deposits. Igneous rocks are the theme of the next two chapters, pp. 360–396; and the last three chapters, pp. 397–450, treat of metamorphism and the metamorphic rocks.

Facing the first page of volume II is a geological map of Europe on a scale of 150 miles to an inch, executed, under the author's direction, by William Topley, F. G. S., and J. G. Goodchild, F. G. S., from the latest surveys. This is a very detailed and valuable map, well printed and colored, the colors being mainly those proposed by the International Geological Congress. A second map in this volume, uniform with those of volume I, shows the probable extent of land covered by ice and snow during the glacial period, their extent now, and the present boundaries of floating ice. In the first chapter, pages 6–18 contain a table of the sedimentary strata in England and their correlation with some of the principal continental groups, and lists of the formations in India, North America, Australia, New Zealand, and South Africa, each of these lists being annoted with some of the characteristic genera of the flora and fauna. The second chapter pp. 19–29, treats of the Archœan rocks. Twenty-five chapters, pp. 30–440, give the history of the Palæozoic, Mesozoic, and Kainozoic eras, and describe their groups of rocks and fossils. Six chapters, pp. 441–535, relate to the Quaternary period. The two concluding chapters are entitled respectively, "Theoretical questions: condition of the earth's crust" (pp. 536–549), and "The primitive state of the earth" (pp. 550–563). Besides the maps mentioned, volume II is illustrated by sixteen plates of fossils, and about 270 well executed wood-cuts, many of them comprising separate figures of several species of fossils. Each volume has an ample index.

Treating of the condition of the earth's mass, the author decides that the hypothesis most compatible with the geological phenomena is that of a central solid nucleus, surrounded by a molten yielding envelope, not fluid but viscid or plastic, measured in thickness not by hundreds, but by tens of miles, while the external solid crust of the earth, so far as geological observations indicate, need not have a thickness of even twenty miles. But the deposition of sediments in great thickness is believed by professor Prestwich to be not a cause, but a result, of continued submergence of their area. He concludes that the earth's crust has become more stable with the progress of the geologic ages, this condition being most marked during the time since the glacial period, so that now the manifestation of its mobility is on a comparatively small scale and in general of extreme slowness, adapting the earth for the habitation of civilized man. Aerolites are considered to be probably fragments of asteroids, affording there-

fore a possible clue to the composition of the deeper seated layers of the earth.

Professor Prestwich traces the history of the glacial period as follows: First, extreme glaciation, an ice-sheet spread upon the greater part of the British Isles, and the formation of the lower boulder-clay or till; second, a depression of 1,500 to 2,000 feet in central England, Wales and Ireland, attended with warm marine currents and a more southern marine fauna; and third, re-elevation, when the warmer currents were diverted or stayed, colder conditions resumed, and Arctic mollusca returned for a time to the coasts of Scotland. The interglacial deposits and vicissitudes of climate shown by them are attributed to "changes in the physiography of Europe," rather than to "the cosmical causes to which the Glacial Epoch, as a whole, was there can be little doubt, due." The author, however, dissents from Dr. Croll's astronomical theory, which would place the glacial period between 240,000 and 80,000 years ago. After comparing the present glaciers of Greenland, which are found to flow 80 to 50 feet a day throughout the year, with the glaciation of the great drift-covered regions during the Ice Age, he says: "My own opinion, based on the facts here named, is—that the time required for the formation and duration of the great ice-sheets of Europe and America (the Glacial Period) need not, after making all allowances, have extended beyond 15,000 to 25,000 years, instead of the 160,000 or more which have been claimed."

The time since the melting away of the ice-sheet is estimated to be 8,000 to 10,000 years or less, making the antiquity of palæolithic man no greater than about 20,000 to 30,000 years. "This view of the question," as the author further remarks, "also brings the geological and anthropological data into close relationship. Palæolithic Man in North-western Europe disappeared with the valley gravels. With the alluvial and peat beds Neolithic Man appeared after an unascertained, but clearly not very long interval geologically speaking. In Europe we are unable to carry back his presence beyond a period of from 2,000 to 3,000 years B. C. But already in Egypt, and in parts of Asia, it is proved that civilized communities and large States flourished before 4,000 B. C. Civilized Man must therefore have had a far higher antiquity in those countries, and probably in Southern Asia, than these 4,000 or 5,000 years; so that comparing Europe and Asia, it is possible that the two periods may have over-lapped, and that while Man had advanced and flourished in a civilized state in the East he may here in the West have been in one of his later Palæolithic stages."

Rock-forming minerals. By FRANK RUTLEY, F. G. S. With 126 illustrations, 252 pp., London, 1888. This is a compact, useful text-book for use in the laboratory and class-room; one of the few in the English language. It describes the essentials of a petrographical microscope, and their use, also the processes of making thin sections of crystalline rocks and the accessory appliances. It is very explicit and satisfactory in the treatment of polarization of light by the different crystal systems.

The common rock-forming minerals, as they occur in thin sections of rocks, are then described, beginning with those of the cubic system and

ending with the triclinic. This is followed by some tables of hardness and specific gravity and of optical constants of the principal rock-forming minerals. For the beginner this is the best book we have seen in the English language, and it will serve well as a reference book for those more advanced.

In the annals of the New York Academy of Sciences, vol. iv, (July, 1888,) is the conclusion of Prof. A. A. Julien's investigation into the cause of the variation of the rate of decomposition of iron pyrites, and its relation to density. One hundred and fifteen samples were subjected to careful examination. These were derived from different parts of America and Europe.

After mentioning numerous hypothetical explanations of this variation, advanced by mineralogists, he gives the results of the chemical analysis of a specimen of spear-headed marcasite from the chalk of Folkestone, England and of another of fibrous, white and brilliant pyrite from near Galena, Ill. The nearness of the actual to the theoretical constitution of pyrite in each case, he considers demonstrative of the absence of all iron proto-sulphide the presence of which had been suggested by Berzelius as the cause of rapid decomposition, through the easy formation of the proto-sulphate, and which has been received generally as the true cause.

He also further concludes that "difference of chemical composition has nothing to do with the differing quickness of tendency to decomposition," and that its cause must be sought in some other direction.

By means of microscopical examination by reflected light, the minute difference of the natural surface was observed in different ways, in a number of samples. Here were noted the following characters: Fineness of grain, distortion of aggregated cubes, concentric lines of growth, staining by tarnish and by efflorescence, and its distribution over the different parts, staining to brownish-black and the depth to which it penetrates, fissures and finer lineation, internal cleavage, the crystals of the efflorescing salt, &c. From the observations made, which are given in detail in the Jour. N. Y. Mic. Soc. (1886) 1-12, Prof. Julien concludes: (1) In the fibrous nodules of pyrites, the outward growth of the elongated cubes, of which the fibers consist, and their mutual compression, have produced a condition of great tension, which has facilitated the later disintegration. (2) The material is mainly composed of a diluted mixture of pyrite with a paler colored and unstable impurity. Through this mixture more or less pure pyrite is diffused in alternating films or in scattered strings and crystals of a deeper yellow color than that of their matrix. (3) The oxidation of the material has been facilitated by its heterogeneous composition, by its fissured structure, and by the tension among its fibers. It has progressed more rapidly in the predominant parti-colored mixture, has penetrated along the seams between the fibers, and has then been hastened by the development of the more minute fissuring, as the result of the tension. (4) The development of this system of minute fissures has furnished an enormous area for the internal condensation of gases and vapors from the atmosphere, chiefly oxygen and moisture, which has resulted in the speedy oxidation, pitting, decay, production of crystals of vitriol, expansion and final disintegration observed in such forms of pyrites. (5) The mode of

oxidation in all forms of pyrite is essentially the same, resulting in the initial production of ferrous sulphate and free sulphuric acid. By the removal, decomposition, or neutralization of the latter, oxidation of the ferrous salt is promoted, which may be then rapidly converted into one or more ferric sulphates, when freely exposed to the air. In the purer forms of pyrite subject to but slow oxidation, the results of decomposition are washed away as fast as they form, and the surface of the mineral retains its brightness, if the grain lies exposed to the air on the surface of a stone; if buried beneath the surface the ferrous sulphate is likely to be immediately converted into a comparatively insoluble ferric sulphate; and from that the ferric oxide may be immediately deposited; if the matrix is calcareous or magnesian, the ferric oxide is deposited at once in place by precipitation, and a hepatic pseudomorph finally results. This material may consequently detain small quantities of lime and magnesia within its pores.

Some general conclusions in regard to variation in decomposition, as derived by Prof. Julien, are as follows: (1) There is a constant association of pyrite with marcasite in intercrystallization and replacement, in the most intimate forms. Wherever the least deviation is noticed from the ordinary physical properties of either mineral the presence of the other may be at once suspected. (2) In regard to marcasite the tendency to decomposition and its absence are plainly associated with other physical properties. When the mineral occurs in the rarer condition of compact, well-formed crystals, with brilliant lustre, greyish white color, and high specific gravity, it resists decomposition as effectively as the stable form of pyrite and as most silicates. But when it occurs in crystals with lower lustre and density, whose color inclines to a greenish tint, or in finely granular, scaly, or columnar masses of lower lustre, density, and purity of color, and in which a little clay and moisture can be detected by analysis, such varieties are certainly inclined to more or less rapid decomposition by efflorescence. (3) The crystals and nodules which are generally assigned to pyrite on account of the crystalline forms of that mineral (cubes, octahedrons, &c.) which the individual grains present, seldom consist certainly of that mineral in a pure condition, save when they also exhibit its characteristic brass-yellow color, high density and luster, conchoidal fracture, and strong resistance to decomposition. When inclined to alteration, however, they invariably exhibit either a paler yellow, whitish or greenish color, a low density and lustre, uneven fracture and tendency to granular or fibrous texture. (4) Correlating then these three facts, the peculiar physical properties of marcasite, its common intermixture with pyrite, and the presence of its other physical properties in most of the varieties of pyrite which show ready alteration, the following conclusion seems inevitable: *All specimens of pyrite in active decomposition are not pure, but are intimate mixtures of marcasite and pyrite, probably in the most minute, i. e., molecular conditions of these minerals.*

The greater tendency to decomposition witnessed in marcasite as compared with pyrite is believed to be due to a more open physical structure, being an interlacing network of spearhead crystals, needles, twins, etc.,

within the interstices of which air and atmospheric moisture are condensed over the entire area and locked up in the most constant and intimate contact; or these invisible cavities may be partially occupied by other sulphides, clay, quartz, etc., whose presence is shown by chemical analysis.

(1.) Discovery of the ancient course of the St. Lawrence river. (2.) Origin of the basins of the great lakes. (3.) Establishment and dismemberment of lake Warren. (4.) Discovery of the outlet of the Huron-Michigan-Superior lake, into lake Ontario by the Trent valley. (5.) Erie the youngest of all the great lakes. BY PROF. J. W. SPENCER, PH. D., F. G. S. (Read at the late meeting of the Am. Assc. Adv. Sci.) (1.) Previous investigations by the author showed that there was a former river draining the Erie basin and flowing into the extreme western end of lake Ontario, and thence to the east of Oswego, but no further traceable, as the lake bottom rose to the north-east. Upon the southern side there was a series of escarpments (some now submerged) with vertical cliffs facing the old channel. By recent studies of the elevated beaches it is demonstrated that the disappearance of this valley is due to subsequent warpings of the earth's crust, and that the valley of the St. Lawrence was one with that of lake Ontario. Recent discoveries of a deep channel upon the northern side of lake Ontario (a few miles east of Toronto) and of the absence of rocks to a great depth under the drift so far beneath the surface of lake Huron between lake Ontario and the Georgian bay, and in front of the Niagara escarpment between these lakes, of the channel in Georgian bay, at the foot of the escarpment, and of the channel across lake Huron, also at the foot of a high submerged escarpment across that lake, show that the ancient St. Lawrence during a period of high continental elevation rose in Lake Michigan, flowed across lake Huron and down Georgian bay and a drift-filled channel to lake Ontario, thence by the present water to the sea-receiving on its way the ancient drainage of the Erie basin and other valleys.

(2.) The two questions involved are "origin of the valleys" and "cause of their being closed into water basins." The basins of lakes Ontario and Huron are taken for consideration. The previous paper upon the course of the ancient St. Lawrence shows that the Huron and Ontario basins are sections of the former great St. Lawrence valley, which was bounded, especially upon the southern side, by high and precipitous escarpments, some of which are submerged. But upon their northern sides there are also lesser vertical escarpments, now submerged, with walls facing the old valley. The valley was excavated when the continent was at high altitude, for the eastern portion stood at least 1,200 feet higher than at present, as shown by the channels in the Lower St. Lawrence, in Hudson's straits and in the New York and Chesapeake bays. The valley was obstructed in part by drift, and in part by a north and north-eastward differential elevation of the earth's surface, due to internal movements. The measurable amount of warping defied investigation until recently, but now it is measured by the amount of uplift of beaches and sea-cliffs. Only one other explanation of the origin of the basins has been given—the "Erosion by Glaciers." (a) Because the latter occur in

glaciated regions. (b) That the glaciers are considered (by some) to erode. (c) The supposed necessity, as the terrestrial warping was not known.

In reply: Living glaciers abrade but do not erode hard rocks and both modern and extinct glaciers are known to have flowed over even loose moraines and gravels. Again, even although glaciers were capable of great plowing action, they did not affect the lake valleys, as the glaciation of the surface rocks shows the movement to have been at angles (from 15° to 90°) to the direction of the side of the vertical escarpments against which the movement occurred. Also the vertical faces of the escarpments are not smoothed off as are the faces of the Alpine valleys, down which the glaciers have passed. Lastly, the warping of the earth's surface in the lake region since the beach episode after the deposit of the drift proper is sufficient to account for all rocky barriers which may obstruct the basins.

(3.) This is the first chapter in the history of the great lakes and is subsequent to the deposit of the upper boulder clay; and therefore the lakes are all very new in point of geological time. By the movements of the warpings of the earth's crust, as shown in the beaches—after the deposit of the later boulder clay—the lake region was reduced to sea level and there were no Canadian highlands northward of the great lakes. Upon the subsequent elevation of the continent, beaches were made around the rising islands. Thus between lakes Erie, Huron and Ontario a true breach is formed at 1,690 feet above the sea, around a small island rising 30 feet higher. With the rising of the land, barriers were brought up about this lake region, producing lake (or perhaps gulf of) Warren—a name given to the sheet of water covering the basin of all the great lakes. A succession of beaches of this lake has been partially worked out in Canada, Michigan, Ohio, Pennsylvania and New York, covering many hundreds—almost thousands—of miles. Everywhere the differential uplift has increased from almost zero about the western end of the Erie basin to three, five, and, in the higher beaches, to from five to nine feet per mile. With the successive elevations of the land this lake becomes dismembered, as described in the succeeding papers—and the present lakes had their birth. The idea that these beaches in Ohio and Michigan were held in by glacial dams to the northward is disproven by the occurrence of open water and beaches to the north, which belong to the same series, and by the fact that outlets existed where placid dams are required.

(4.) With the continental rise described in the last paper—owing to the land rising more rapidly to the northeast—lake Warren became dismembered, and Huron, Michigan and Superior formed one lake; the Erie basin really was lifted out of the bed of lake Warren and became drained, and Ontario remained a lake at a lower level. The outlet of the upper lake was south-east of Georgian bay by way of the Trent valley into lake Ontario at about sixty miles west of the present outlet of this lake. The waters of this upper lake were 26 feet deep over this outlet into the Trent valley, and long continued to flow through a channel from one to

two miles wide. It has cut across a drift ridge to a depth of 500 feet, as the whole area has been rising. With the continued continental uplift to the north-east (which has raised the old beach at the outlet about 800 feet above the present surface of lake Huron) the waters were backed southward and overflowed into the Michigan basin and into the Erie, thus making the Erie outlet of the upper lakes to be of recent date. This is proven by the fact that the Georgian beach which marked the old surface plane of the upper great lake descends to the present water level at the southern end of lake Huron, and is beneath the surface of the water upon its south-western side as the uplift, which has been measured, was to the north-east.

(5.) The Erie basin is very shallow,and upon the dismemberment of lake Warren, was drained by the newly constructed Niagara river, (except perhaps a small lakelet south-east of Long point, Subsequently, the Northeastward warping (very much less in quantity than farther northward at the Trent outlet) eventually lifted up the rocky outlet and formed Erie into a lake in recent times, thus making Erie the youngest of all the lakes. The beaches about Cleveland are not those of separated lake Erie, but those of the older and original lake Warren.

"*Les dislocations de l'ecorce terrestre.*" BY MM. DE MARGERIE & HEIM. In this work the authors have given an exhaustive monograph on the various kinds of displacements occurring in the crust of the earth, their appearance and their effects. Beginning with a simple fault in horizontal strata, they discuss the different kinds of faults and their results on the strata, horizontal or inclined, in which they occur. A simple flexure forms the text for a chapter on the complicated consequences of such flexure on strata. Faults of displacement such as result from the above are then distinguished from faults produced by folding and the authors then take up the results of horizontal pressure in producing folds, developing anticlines and synclines, overthrows, thrust planes, thickening of the arches and troughs and thinning of the intervening portions, fan-structure, such as is exhibited in the High Alps and the complete separation of the points of the anticlines and synclines by the forward shoving of the folds, ending in severance of the sides. The effects of horizontal pressure in forming "heaves" and so displacing the adjacent edges of strata come in next for treatment and are followed by the important and interesting topic of the actual length of the folded beds and their present horizontal extent.

The folding a second time of strata already once crumpled is next considered and the many complicated phenomena resulting therefrom are well and fully illustrated, showing how intricate may be the consequences resulting from a comparatively simple cause.

The authors merely glance at the subjects of the origin of faults and mention in conclusion some of the secondary effects of folding such as "marmorization," "metamorphism," &c., saying that these topics are not yet sufficiently investigated to allow of full consideration.

The work forms a complete summary of the kinds of faults and the mode of their formation and will be of much value to all students of physical geology.

RECENT PUBLICATIONS.

1. State and government reports.

A description of the desiccated human remains in the California State Mining Bureau. By Winslow Anderson, M. D. Bulletin No. 1. of the *State Mining Bureau.*

The iron ores east of the Mississippi river. By John Birkinbine. Abstract from "*Mineral resources of the United States,*" 1887.

Report on the geology of a portion of the eastern townships relating more especially to the counties of Compton, Stanstead, Beauce, Richmond and Wolfe. By R. W. Ells. Part J of the annual report (1886) of the *Canadian geological survey.*

2. Proceedings of scientific societies.

Palæolithic man in eastern and central North America. *Peabody Mus. Am. Arch. and Eth.*, Cambridge, May, 1888. Consists of reprints from the Proceedings of the Bos. Soc. Nat. Hist. vol. xxiii. and contains articles by *F. W. Putnam, C. C. Abbott, G. Frederick Wright and Warren Upham,* with a discussion by *Henry W. Haynes, E. S. Morse* and *F. W. Putnam.*

The journal of the *Cincinnati Society of Natural History,* vol. xi., No. 1, contains a valuable paper on the monticuliporoid corals of the Cincinnati group, with a critical revision of the species, by U. P. and Joseph F. James.

3. Papers in scientific journals.

Am. Jour. Sci., July No. History of changes in Mt. Loa craters. J. D. DANA. Summit crater of Mt. Loa crater in 1880 and 1885. BRIGHAM and ALEXANDER. Bertrandite from Mt. Antero, Colorado. S. L. PENFIELD. Some localities of Post-tertiary and Tertiary fossils in Massachusetts, W. W. DODGE. A cordierite gneiss from Connecticut, E. O. HOVEY. *August No.* History of changes in the Mt. Loa craters (II.) on Mokuaeoweo. J. D. DANA. The Fayette county, Texas, meteorite. WHITFIELD and MERRILL. Evidence of the fossil plants as to the age of the Potomac formation. LESTER F. WARD. *September No.* Cambrian fossils from Mount Stephens, Northwest territory of Canada. CHAS. D. WALCOTT. History of changes in the Mt. Loa craters. Relations of Kilauea to Mt. Loa. J. D. DANA. On the origin of primary quartz in basalt. J. P. IDDINGS. Mineralogical notes. By GEO. F. KUNZ. *October No.* The structure of Florida. L. C. JOHNSON. Rosetown extension of the Cortlandt series. J. F. KEMP. The contact-phenomena of the "Cortlandt series" on the adjoining mica-schists and limestones. G. H. WILLIAMS. The sedentary habits of Platyceras. C. R. KEYES. Edisonite, a fourth form of titanic acid. W. E. HIDDEN. Two new masses of meteoric iron. G. F. KUNZ. Preliminary notice of Beryllonite, a new mineral. E. S. DANA.

The Canadian Record of Science. On Sporocarps discovered by Prof. Orton in the Erian shale of Columbus, Ohio. SIR J. WILLIAM DAWSON. Notes on graptolites from Deese river, B. C. PROF. CHARLES LAPWORTH. The great lake Basins of Canada. A. T. DRUMMOND.

American Naturalist, May No. Mountain Upthrusts. By CHARLES A. WHITE. Notes on the Geology of Johnson County, Iowa. CLEMENT

L. Webster. *July No.* Megalithic monuments of Brittany. Thomas Wilson. Dr. N. O. Holt's studies in glacial geology. Dr. Josua Lindahl.

4. *Excerpts and individual publications.*

Microscopic petrography of the drift of central Ontario. By A. P. Coleman. *Trans. Roy. Soc. Canada*, May, 1887. Two colored plates of thin sections.

On the rocks occurring in the neighborhood of Ilchestor, Howard county, Maryland; being a detailed study of the area comprised in sheet No. 16 of the *Johns Hopkins University* map. By Wm. H. Hobbs.

Report on the water-power of St. Louis river. (Minnesota) John Birkinbine. 34 pages, with map.

A history of New Brunswick geology. By R. W. Ells, of the Geol. Survey of Canada. 64 pp. Montreal.

Bulletin of the scientific laboratories of Denison University; vol. iii. 137 pp. 15 plates; contains the Clinton group of Ohio, Part IV, chemical and stratigraphical geology and geographical paleontology. By A. F. Foerste; the geology of Licking county, Parts III. and IV. Sub-Carboniferous and Waverly groups. By C. L. Herrick; Notes on paleozoic fossils, By A. F. Foerste.

Changes of Level of the Great Lakes. G. K. Gilbert. *The Forum*, June, 1888.

Geological history of the Yellowstone National Park. By Arnold Hague. *Trans. Am. Inst. Min. Engineers.* Vol. xvi, 1888.

Values in classification of the stages of growth and decline with propositions for a new nomenclature. Alpheus Hyatt. *Proc. Bos. Soc. Nat. Hist.* March, 1888.

Evolution of the faunas of the Lower Lias. Alpheus Hyatt. *Proc. Bos. Soc. Nat. Hist.* Vol. xxiv, 1888.

The coals of Colorada. By J. S. Newberry. *School of Mines Quarterly*, Vol. ix, July, 1888.

The Great Lakes and their relations to the lakes and gulf water-way. Osian Guthrie. 8 vo. 31 pp. 1888.

The ethical functions of scientific study. Address of president Thomas C. Chamberlin, of Wisconsin state university at the annual commencement of University of Michigan. Ann Arbor, published by the university, 1888.

On the joint structure of rocks. 8 vo., 5 pp. W. O. Crosby.

Metheds of instruction in mineralogy and structural geology in the Massachusetts institute of technology. Read before the *Am. Soc. of Naturalists.* New Haven, Dec. 29, 1887. W. O. Crosby.

Geology of the outer islands of Boston Harbor. *Proc. Bos. Soc. Nat. Hist.* Vol. xxiii, 1888. W. O. Crosby.

Quartzytes and siliceous concretions. *Technology Quarterly*, May, 1888. W. O. Crosby.

The geology of the Black Hills. W. O. Crosby. *Proc. Bos. Soc. Nat. Hist.* Vol. xxiii, 1888.

The glacial striæ of the Lackawanna—Wyoming region. Prof. John C. Branner. *Proc. Lackawanna Inst. Hist. and Sci.* Vol. i.

Glaciation: Its relations to the Lackawanna—Wyoming region. A lecture delivered before the Lackawanna Institute July 3,1886. John C. Branner.

5. *Foreign Publications.*

Nouvelles recherches sur l'origine du nom d'Amerique, par Jules Marcou. *Soc. de Geog.*, Paris, 1888.

Sur les cartes geologiques a l'occasion du "Mapoteca geologica Americana,"par Jules Marcou. *Ex. des Mem. de la societe d' emulation de Doubs*, April, 1887.

On the mammaliferous gravel at Elloughton in the Hamber valley. Report on the buried cliff at Sewerby, near Bridlington on the larger boulders of Flambro Head, part 1. The last three are by Mr. G. W. Lamplugh and are extracted from the *Proceedings of the Yorkshire Geological and Polytechnic Society*. Vol. ix., 1887.

Report on the geological features of the Mackay district, Queensland, Townsville, November, 1887. By Robert L. Jack. Ten pages folio, with two maps.

Anniversary address of the president of the Roy. Soc. N. S. W., delivered May 2, 1888. By C. S. Wilkinson F. G. S.; treats of New South Wales—a field for geological investigation.

Ueber einige mikroskopisch-chemische Reaktionen; von A. Streng, in Giessen. *Neues Jahrb, 1888, Bd. II.*

CORRESPONDENCE.

Prof. N. H. Winchell *has referred to the writer* two small specimens of quartzite sent to him by Mr. Vernon Bailey, who says: "I broke them from rocks along the road from Niobrara to O'Neil, Neb. It was the only kind of rock seen between the places, and this was abundant, as large angular bowlders. Some hills near the Niobrara river were thickly strewn with them. The country where it was found is all sand and pebbles—no bowlders of any other kind. Evidently it is of the Sioux Falls or Pipestone formation, though I have never seen any of just the color. Perhaps you can tell near where it came from."

The specimens are of a pale yellowish green color, resinous lustre, and fracture like obsidian. These characters do not agree at all with the Sioux Falls quartzite, but they do agree closely with a Tertiary quartzite seen at Valentine, Nebraska. A small weathered surface on one specimen indicates that the rock weathers gray, which also agrees with the Valentine quartzite.

The region between Niobrara and O'Neil is colored green for Cretaceous in the maps of the U. S. Geologists, and the occurrence then of a Tertiary stratum scattered over the hills probably indicates a former extension of the Tertiary to the eastward some seventy-five miles, the softer portions having been eroded away, leaving the hard quartzite as a witness of the previous existence of the Tertiary in that region. The abundance

and angularity of the blocks forbid the supposition that they are ice-borne boulders from a distance. If they do not prove to be outliers of the Valentine quartzite they may be a local quartzite in the Cretaceous not hitherto described.

I recall the fact that when I first encountered the Valentine quartzite in scattered fragments, I took them to be boulders, but quickly corrected myself by tracing them to a thick stratum *in situ* on the Minnechadusa river. The Valentine quartzite contains free gold in minute quantities, as noted in this journal for February, vol. i, page 187.

L. E. HICKS.

SOME FORGOTTEN TACONIC LITERATURE.

1819, *Dewey C.*) Am. Jour. Sci. vol. 1., 1819, p. 327.) Sketch of the Mineralogy and Geology of the vicinity of Williams College, Williamstown, Mass.

The rocks and minerals are mentioned in the following order: (1.) *Granite*, Oakhill, both sides of the Hoosack; Vortex of Pownal Mountain. (2.) *Gneiss* and Mica slate, Hoosack Mountain, Saddle Mountain, etc. (3.) *Quartz*, north-east part Saddle Mountain, Stone Hill; Argillaceous slate rests on the quartz on east side of Stone Hill; also at the base of Hoosack Mountain, which extends round the north side of the Hoosack to Oak Hill, which is wholly composed of it, etc. (Middle Cambrian of Walcott.) (4) *Granular limestone*, abundant at the Cave or Falls in Adams, and on both sides of the Hoosack. On the west bank of the Hoosack and east base of the hill, white limestone is found resting on the Mica slate at the west of it, etc. (5) *Argillaceous Slate* rests on quartz on Stone Hill and is also found low down in the valley connected with limestone. It constitutes the hill (P) connected with the Taconic range and also Northwest hill, (O) whose base is compact limestone. A few miles north, this slate is distinctly marked and is about 12 miles from hills of roof slate in Hoosack, N. Y.

* * * *

1824, *Dewey C.* with the assistance of his pupil, *Dr. E. Emmons*, published a geological map of the county of Berkshire, Mass., and of a small part of the adjoining states. (Am. Jour. Sci. vol. 8, 1824, p. 1.)

The rocks are arranged in the following order on the map given in this report:

Granite, Gneiss, Talcose Slate, Mica Slate, (Primary.)

Quartz, Primitive limestone, Primitive Argillite. (Upper Primary.)

Transition limestone &c. (New York System.)

These sketches are given to show the school of geology under which Dr. Emmons was instructed; and also the origin of the "Taconic System" which appeared in 1842.

* * * * *

1842. *Emmons E.* Topography, Geology and Mineral resources of the State of New York. (A. Gazetteer of the State of New York, etc., Albany, 1842. J. Disturnell, March, 1842, p. 11.)

Emmons on the Taconic System.

"Upon the eastern border of New York, adjacent to Vermont, Massachusetts and Connecticut, is the prolongation of the Appalachian chain of mountains. This portion of the chain is known as the *Taghkanic range*; it rises to an elevation of from 1,200 to 2,000 feet, and presents a tolerably regular outline throughout its whole extent. Its geological relations are interesting, particularly so, as many of the phenomena in connection with these rocks bear upon the doctrine of *Metamorphism*, and probably there is no better field for proving or disproving the doctrine, than the one under consideration.

"*The rocks of course are situated between the gneiss of Hoosick mountain on the east and the Slates of the transition on the west.* They occupy, therefore geographically as well as geologically an intermediate position; the rocks on the one hand bearing a very close resemblance to the Primary on the east, and on the other a great similarity to the transition slates on the west. Still, as a whole, the rocks of the Taghkanic range may generally be distinguished from those on either side, their general character being derived from the presence of a large proportion of magnesia which imparts to the rocks a softer feel and a peculiar greenish color. *It is not proposed in this plan to separate these rocks from the Primary, but to consider them as belonging to the upper portion, and to speak of them as the Taghkanic rocks, or perhaps as the Taghkanic System.* There may be many objections to this proposition; this is not, however, the place to consider them, but we may inquire whether it may not, upon the whole, be expedient to consider them under a distinct head; and is it not true, that so long as they are merged in the great mass of the primary, or as a portion of the gneiss system, less will be known of them, and less interest be entertained for them. Considering them for the present as belonging to the *Upper portion* of the *Primary*, the Taghkanic rocks will be composed first of a peculiar *talcose slate* or a magnesian slate in part; in other parts it is Plumbaginous, which strongly soils the fingers. Its associated minerals, are milk-white quartz. * * * Second, of *white, gray and clouded limestone*, varying in texture from fine to coarse granular, often interlaminated with slate, the latter often merely coloring the limestone so as to impart that clouded appearance. Serpentine is never connected with this variety of limestone. Third, of *granular quartz*, or a sandstone generally siliceous and of a brown color * * * (Cambrian of Walcott.)

"There are two or three facts connected with the subject which require to be stated in this plan, inasmuch as they bear on the question of the propriety of separating the Taghkanic rocks, from the gneiss system. The granular quartz, and one of the varieties of the slate, and also the limestone, contain minerals in a few instances, belonging to primary rocks; thus feldspar occurs in the first, needle-form schorl in the second and brown tourmaline in the third. Again, there are masses of the granular quartz, which appear like conglomerates, and the whole *Taghkanic System is clearly stratified and is wholly unconnected with gneiss*, serpentine granite, sienite, steatite or hornblende. *Mica slate* with garnets, however, does occur in masses among the rocks of the Taghkanic System, and this may be considered as a strong argument against the separation of the rocks, as

proposed. The talcose rocks are, however, clearly different from those of the gneiss system, or those east of the Hoosick mountains, and the Mica slate may come up among the Taghkanic rocks and yet on a careful observation be found to be distinct from them. We believe this will be found to be the fact. On the whole in regard to those rocks we have denominated 'Taghkanic,' we believe they ought to be separated from those on the east, being as a whole, clearly distinct from them."

Tabular view of the Rocks of New York, arranged in Systems and Groups.

I. POST-TERTIARY.

Alluvial, Diluvial, Clays and sands of the Post-tertiary.

II. OLD RED SYSTEM.

Old red sandstone.

III. N. Y. TRANSITION SYSTEM.

Erie Group.

Chemung sandstones and flags, Ludlowville shales.

Helderberg Series.

Helderberg limestones, Schoharie grit, brown argillaceous sandstone, encrinal lime stone, Oriskany sandstone, green shaly limestone, Pentamerus limestone.

Ontario Group.

Onondaga salt and gypseous rocks, limestone and green shales, argillaceous iron ore, soft red, green and variegated sandstones, or Medina sandstone.

Champlain Group.

Gray sandstone and bed of conglomerate, Lorraine shales and roofing slates, Utica slate, Trenton limestone, Birdseye limestone, Chazy limestone, Calciferous sand-rock, Potsdam sandstone.

IV. TAGHKANIC SYSTEM, (Quartzite.)

Light green slates sometimes dark and plumbaginous (middle Cambrian, Walcott.) Gray and clouded limestones, (Hudson River, etc., Walcott.) Brown sandstones, (Cambrian, Walcott.)

V. GNEISS SYSTEM.

Gneiss, Hornblende and Mica slate, Talcose slate and steatite.

VI. SUPERINCUMBENT ROCKS.

Greenstone trap—porphyry.

VII. UNSTRATIFIED ROCKS.

Granite, Hypersthene rock, primary limestone, serpentine, rensselærite, magnetic iron ore.

Dr. Emmons remarks, (*Am Quart. Jour. Agl. and Sci. vol.*, IV, 1846 p. 202.) that the first hints published in regard to the Taconic system appeared in *Disturnell's State Register*, for which he wrote a brief article on the geology of the state of New York. He states, "In making up our notes for this object we found it necessary to fix upon some general subdivision of the rocks belonging to the state. We drew up an abstract of the plan and submitted it to the criticism of the Rev. Prof. Dewey of Rochester * * * Prof. Dewey approved of the division proposed in the main. It resulted in separating the rocks in the vicinity of the Taconic range, both from the Primary and the New York transition, as we then called them."

The subdivisions then proposed in *Disturnell's State Register*, and which were adopted in the report of the state geologists (Geol. N Y., Part ii, comprising the survey of the second Geol. District, by Ebenezer Emmons Albany 1842, published May 26, 1843) were (1) Primary, (2) Taconic, (3)

New York system divided into Champlain Ontario, Helderberg, Erie and Catskill divisions. A. W. VOGDES.

Fort Hamilton, N. Y. Sept., 1888.

GEOLOGY OF THE VICINITY OF QUEBEC CITY.—In the August number of the *American Geologist*, p. 134, Mr. A. R. C. Selwyn claims that he first intimated in 1879 that "the so-called Quebec rocks of the town of Quebec are not of Quebec age at all" as professor Lapworth says, in his paper of 1886, and he congratulates himself that professor Lapworth "fully confirmed his views." On the contrary professor Lapworth instead of regarding the rocks of the town of Quebec as being the equivalent and a sort of special facies of the Utica Lorraine group, *above* the Trenton, as Mr. Selwyn thinks, referred them to a group *below* the Trenton, without assigning them to any special position in the different groups existing between the Point Levis group and the Trenton, a difference of the first order between the two observers.

Many years before Mr. Selwyn, I described, in 1862, "the great group of black slates of the city and citadel of Quebec" as a special formation, entirely distinct from the Point Levis group, and above it; and I have regarded that special group as contemporaneous with the Swanton slates of Vermont (See *Letter to M. Joachim Barrande, on the Tacónic rocks of Vermont and Canada*, p. 12. and the *Tabular view* accompanying, Cambridge, 1862.)

Mr. Selwyn adds: "The stratigraphy which professor Lapworth has no knowledge of, has been carefully worked out by Logan and myself, and by other members of the Canadian survey, and I cannot learn that any one ever saw the shales beneath the Trenton limestone, as shown in Mr. Marcou's section fig. 8." But Mr. Selwyn fails entirely to say what rocks the Trenton limestone lay over; his negation of my observations has no base to rest upon. On the edge of the plateau of Tresplat, at less than fifty feet from an out-crop of slates dipping S.S.E. at an angle of 45 degrees, the Trenton limestone lies horizontal, and is only fifteen feet thick. I saw the slates at two quarries, on the plateau, in 1849 and in 1862. It will not be difficult for members of the Canadian survey to see the contact of the two groups of rocks, by direct diggings, if not otherwise.

In regard to Dr. Emmons' "Geology of Montmorency," 1847, I have read that paper many years before Mr. Selwyn came to Canada, and I am glad to see it re-printed in full in *The American Geologist*, August, p. 94. Emmons did not find a fault, but only says: "This association of rocks taken in connection with their position, indicates some derangement; and a close examination would undoubtedly result in the discovery of an extensive fault, or uplift, along the line which the road passes." Only a hint, passed over entirely by Logan fourteen years later. Dr. Emmons did not go to Charlesbourg, and consequently did not see my section with the Charlesbourg shales under the Trenton limestone.

The "landslides" are evident on both sides of Montmorency falls. Big packs of Trenton limestone are seen now, resting on the asperity of the quartzite on which they hang, on the right side of the fall. At my last visit, in August 1863, the water was very low, and I was able to approach and

survey carefully the bottom of the fall. Contrary to Logan's section of 1861, there is no Trenton limestone; showing that the packs of limestone fallen from the top, have been destroyed and carried away. But more, there are no Utica and Hudson River slates, as marked at the bottom of the fall, on the section of Mr. Selwyn of 1884. The bottom of the fall, and to a distance of forty feet from the foot of the fall, is formed of the same quartzite rocks as the fall. (Called Laurentian gneiss by Mr. Selwyn.) Lying against the quartzites are gray shales, alternating with layers of marly limestone, without fossils dipping S. S. E. at an angle of seventy degrees. They belong to the City and Citadel Hill of Quebec group or Swanton slates.

At Petit Ruisseau, west of Charlesbourg, the "landslides" of the Trenton over the Taconic slates can be seen at different places, specially below the Mill.

At Indian Lorette the landslides are conspicuous.

Mr. Selwyn speaks of "Mr Marcou's not very complimentary remarks in reference to Logan and himself." I have carefully quoted their views and opinions, on their three large faults of what Mr. Selwyn calls "*supposed* structure from Montmorency falls to the island of Orleans;" when both of them have passed over contemptuously, without any reference whatever, my observations at Montmorency, published in 1860, 61, and 62, as if I had never published anything on the Geology of Quebec city and its vicinity. Perhaps Mr. Selwyn regards it as complimentary.

As to placing the Taconic system "on a par with the Quebec group and like it," Mr. Selwyn in this adds a new example of the confusion so persistently made, and it shows how difficult it is to establish a proper case for the discussion of each contested point in the stratigraphy and paleontology of the Taconic region, as well in Canada as in the United States.

Cambridge, Mass, August 14, 1888. JULES MARCOU.

The position of the Olenellus beds. There are circumstances which are more than perplexing. Such is, for example, the tenacity with which Messrs. Walcott and Ford still adhere to the opinion that the strata with Olenellus should be younger than the Paradoxides beds, in spite of the fact that, as myself, Linnarson and Brogger have shown, the former invariably have their position underneath the latter; and when so proven Messrs. Walcott and Ford express doubts whether our Olenellus is a true Olenellus! It is also most astonishing to see Mr. Walcott describe a great number of primordial trilobites as new genera while they are most nearly allied and probably often even identical with European species known long ago. A. G. NATHORST,

Royal Museum, Stockholm, September 9, 1888.

*Dr. Rominger's rejoinder to Mr. C. D. Walcott.** Mr. Walcott finds fault in my not having made an attempt to give the stratigraphic position of the fauna by making comparison with published sections or with the species of similar form that have been described from the Cambrian strata

* Dr. Rominger's descriptions of primordial fossils from Mr. Stephen were published in the July number of the *Proc. A. of Nat. Sciences* of Philadelphia, in 1887. Mr. Walcott's criticisms are found in *Amer. Jour. of Science* for Sept, 1888.

of the Rocky Mountains. To the first objection,I answer that I considered it premature to enter into any speculations about the relative position of a lot of fossils of apparently new form accidentally picked up by a transient traveller, who had no time for examination of the stratigraphic position of the beds. I thought so, the more as I determined as soon as I saw the fossils, to go and see the locality myself; I have done this since, and succeeded in gathering an abundance of the already described specimens, but I did not find, as I had expected, any notable amount of additional new forms of sufficient importance to call for a special publication. Also the stratigraphy of the huge mountain mass I found so complicated, that the short time I could devote to the investigation of the locality appeared to me insufficient to ascertain the stratigraphic order of the exposures. I desisted therefore from such attempt, as it would have required weeks or even months of dangerous work on almost inaccessible mountain slopes scarcely possible for a single person without any assistance, and not provided with camping equipments.

These are my reasons why I did not make a further communication about Mount Stephen, its geological structure, and its fossils. Incidentally I may here make the statement that the base of the mountain is pretty well exposed by cuts of the Canadian Pacific Railroad. It consists of a very large succession of granular Quartzite beds,some of them perforated with frequent vertical tortuous channels known as Scolithus, but no other recognizable organic remains. Inter-stratified with the quartzite beds are belts of bluish or greenish dark slate rock more or less fine grained and silky, shining or in other cases dull, earthy,gritty,or calcareous. In one of these slate seams cut by the road bed, I found sparingly fragments of Conocephalus cordilleræ or as Mr. Walcott prefers, of Ptychoparia, likewise are minute Linguloid shells or Obollelas here and there scattered, and in one slab I noticed a fragment of the head of Ogygia klotzii. In the upper horizon of theQuartzitic series, beds of a dark blue siliceous limestone are intercalated, and higher still a belt of dark blue limestone many hundred feet in thickness shows its face in the unaccessible rockwalls. No fossil could be discovered in the limestone blocks tumbled down from above.

The strata,inclosing a prolific number of well preserved specimens of Trilobites, but a very restricted number of species, are evidently superincumbent on these limestones and present themselves in precipitous,scarcely accessible slopes of slate rock 3,000 feet vertically above the railroad track. The succession of beds in this slate belt amounts to not less than a thousand feet, the fossils occur principally in the uppermost layers. In the lower ones I found none. Above the slate beds carrying the Trilobites a repeated alternation of quartzite beds and of belts of limestone with a series of sericitic slates forms unaccessible rockwalls, up to the top of the snow covered mountain. These upper sericitic slates are on the line of the road west of Mt. Stephen largely exposed and seem to compose entire mountains from bottom to the top; they are as far as I could ascertain totally devoid of fossils.

The second objection of Mr. Walcott, that I neglected to compare the fossils with similar forms described from theCambrian strata of the Rocky

Mountains I consider to be unjust. Looking over the published records accessible to me, including Mr. Walcott's Paleontology of the Eureka district, I found nothing which allowed a positive identification with the material before me; the majority of the described forms were only imperfect fragments and of only few of them a satisfactory description of the entire body could be given, while the specimens from Mount Stephen were all nearly complete and exhibited features which I could not discover in the described forms. I therefore came to the conclusion that even if they were not all new forms as I had reason to suppose, the perfection of the specimens would make it any way desirable to have them accurately described. I did this, not however induced by a spirit of vanity claiming the discovery and naming of a half dozen new forms, but I simply wished to add without delay to the rapidly accumulating number of new facts concerning primordial faunas, a few more, which might help for their further elucidation and furnish the means for drawing analogies between different remote localities. I myself did at the moment,not feel sufficiently prepared to enter into such comparative speculations and therefore restricted my communication to an unsophisticated description of what I saw before me. Mr. Walcott finds my determinations of the forms in question generally incorrect. For two of them he claims for himself the priority of a description (Embolimus spinosus and Embolimus rotundatus); moreover he informs that the name Embolimus is already preoccupied, and proposes a name of his own. The specimens named by me Ogygia serrata are according to him identical with Paradoxides (Olenoides) nevadensis of Meek. Two forms only he allows as previously undescribed; but what I happened to designate with the old fashioned name Conocephalites is for him a Ptychoparia and the very characteristic representative of the genus Ogygia. Ogygia klotzii bears in his critical note a mark interrogation behind the generic name.

In reply to this I very willingly declare, that after I saw Mr. Walcott's publication in the 30th Bulletin of the U. S. Geol. Survey,I do not hesitate a moment to acknowledge his priority in description of the two forms which I had named Embolimus, but I have to remark that Mr. Walcott's paper, was not yet in the hands of the public at the time my manuscript was finished and handed over for publication to theSecretary of the Acad. of Sci. at Philadelphia; therefore, under the existing circumstances I was fully justified to consider these forms as new.

My first impulse in selecting a name,for the two mentionedTrilobites,was to pay a tribute to Mr. Walcott's merits as a paleontologist. The two forms although differing some in general aspect, closely resemble each other in the configuration of their heads and in the number of thoracic segments. I used therefore, for generic designation of both of them, the name Walcottia in the original manuscript, sent to the Philadelphia Academy of Science for publication.

Later I happened to discover that Miller and Dyer had already preoccupied the name Walcottia for a fossil of problematic affinities and being compelled to substitute another name, I chose to select *Embolimus*, a well-sounding word which means *a substitute*, but I had bad luck in this affair,

as Mr. Walcott informs, that also this rather unusual name is likewise already preoccupied. In place of it he recently proposed the name *Zacanthoides*, as the name Olenoides, which is applied by him in Bulletin 30 of the U. S. Geol. Survey for what I named Embolimus spinosus, is not tenable, on comparing that form with the type form of Olenoides. The second species of Embolimus (rotundatus) Mr. Walcott places under the newly created genus Bathyuriscus, which according to his statements has eight thoracic segments, while all the numerous specimens of this form, collected at Mt. Stephen, invariably have nine thoracic segments; nevertheless on comparing his figures with the specimens from the before mentioned locality, I do not doubt their specific identity and his right to claim priority in description of the species, as most likely only a mistake in counting the segments caused the apparent difference.

The form associated by me with Ogygia, under the name *O. serrata* is claimed by Walcott to be a typical representative of Meek's species *Paradoxides nevadensis* afterward changed into *Olenoides nevadensis*; but the figure of the type specimen given by Walcott represents so imperfect a specimen, that an accurate identification with the well preserved specimens of Mt. Stephen is scarcely possible. A certain similarity exists undoubtedly, but we are told eight or more thoracic segments are the normal number for the genus Olenoides, while all the numerous specimens from Mt. Stephen have but seven, never more.

With regard to the other fossils, partly only mentioned by me, withou description or figures, Mr. Walcott identifies the specimen figured as Agnostus with A. interstrictus White, of what I compared with Menocephalus salteri he thinks it might possibly be a young individual ofBathyuriscus howelli the correctness of which suggestion I am inclined to dispute, although I do not insist on the correctness of my comparison with Menocephalus.

Also Mr. Walcott's inference, that the remains supposed by me to begraptolites, might be slender specimens of Hyolithellus is erroneous. In order to give him an opportunity to form on all the concerned objects an independent opinion of his own he is welcome for the loan of all the specimens concerned if he should wish so.

PERSONAL AND SCIENTIFIC NEWS

THE PAPERS READ BEFORE SECTION E at the late meeting of the Am. Assc. Adv. Sci. at Cleveland, were as follows:

The geological history of the Ozark uplift. By G. C. Broadhead.

The Archimedes limestones and associated rocks in north-western Arkansas. By F. W. Simonds.

Systematic results of a field study of the Archæan rocks of the Northwest. By Alexander Winchell.

The use of fossils in determining the age of geologic terranes. By Henry S. Williams.

The terraces of the Missouri. By J. E. Todd.

Extra morainic striæ in the Missouri valley. By J. E. Todd.

Boundary of the glaciated area in Dakota. By G. F. Wright.

Evidences that the Mohawk river, at a very remote period, changed its channel of drainage. By A. S. Tiffany.

The Cleveland Shale and its fossil fishes. By J. S. Newberry.

Discovery of Sporocarps containing Protosalvinia huronensis in the Ohio shale. By Edward Orton.

The recently discovered sources of oil and gas in Ohio, Indiana and Kentucky. By Edward Orton.

A new gas well at Cleveland. By H. P. Cushing.

Geology of Cleveland. By H. P. Cushing.

The ancient channel of the Ohio at Cincinnati. By Jos. F. James.

Ivorydale well in Mill Creek valley. By Jos. F. James.

Notes on the preglacial drainage of western Pennsylvania. By P. Max Fashay.

I. Discovery of the ancient St. Lawrence river.

II. Origin of the basins of the great lakes.

III. Establishment and dismemberment of lake Warren.

IV. Discovery of the outlet of the Huron-Michigan-Superior lake to lake Ontario by the Trent valley.

V. Erie the youngest of all the lakes. By J. W. Spencer.

On the intensity of earthquakes with approximate calculations of the energy involved. By T. C. Mendenhall.

On the trap dikes at Kennebankport, Maine. By J. F. Kemp.

Some thoughts on eruptive rocks with special reference to those of Minnesota. By N. H. Winchell.

The distribution of the granites of the northwestern states, and their general lithologic characters. By C. W. Hall.

The geologic age of the crystalline rocks of Arkansas. By J. C. Branner.

The peridotites of Pike county, Arkansas. By J. C. Branner and R. N. Brackett.

Some physiographic notes on north-eastern Minnesota. By C. W. Hall.

The oil field of Colorado. By J. S. Newberry.

Evidence that lake Cheyenne continued till the ice-age. By J. E. Todd.

The discovery of fossil tracks in the Triassic of York county, Pennsylvania. By A. Wanner.

Recent discovery of rock salt in Kansas. By R. Hay.

On the occurrence of the forest-bed beneath intra-morainic drift. By Frank Leverett.

On a new method of constructing geologic maps. By J. T. B. Ives.

The age and correlation of the Mesozoic rocks of the Sergipe-Alagoas basin of Brazil. By J. C. Branner.

Probable derivation of the terrestrial spheroid from the rhombic dodecahedron. By R. Owen.

Additional facts respecting the law governing the distribution in space of seismism. By R. Owen.

The Cretaceous deposits of North America. By C. A. White.

Chalk in the North American Cretaceous. By R. T. Hill.

IN RESPONSE TO THE CIRCULAR CALL which was printed in the GEOLOGIST (vol. i. p. 394,) the geologists of Sec. E. assembled on the day before the opening of the session and after full and earnest discussion appointed a committee to present a constitution and by-laws for the organization of the *American Geological Society*. These were read and adopted on the following day. The committee of organization was directed to proceed with the steps required by the constitution for completing the organization, securing the necessary membership and calling the first meeting. This committee consists of Profs. A. Winchell,

J. J. Stevenson, C. H. Hitchcock, Edward Orton and John Proctor. The constitution requires one hundred members before it becomes operative. The annual dues are placed at ten dollars. The original members (styled "fellows") must be members of the American Association for the Advancement of Science. There will be two meetings each year, one being required to be at the same time and place as the annual meeting of the Association. Before the adjournment of the session thirty-three persons had joined the new society. Correspondence respecting it should be addressed to Dr. A. Winchell, Ann Arbor, or to Prof. J. J. Stevenson, New York.

At the May meeting of the Royal Society of Canada the president, Dr. Bell, read an address giving an account of "the Huronian system of Canada," in which the author sketched the history of the work which has so far been done on these rocks in Canada and the United States. After the Canadian geological survey had worked on them for 45 years, some American geologists have begun on the same system. One of them, Prof. R. D. Irving, had proposed to separate a part of the system as the only part entitled to be called Huronian, but made no provision as to what should be done with the rest. Prof. Bell defended the course which had been pursued by the Canadian geologists, and he was endorsed by remarks made in the following discussion by Drs. Selwyn and Dawson, and by Prof. Bailey, all of whom urged the inadvisability of attempting to divide these rocks. Dr. Bell, in his description dwelt on the one great feature of the Huronian—the prevalence of a volcanic character throughout its whole thickness, the crystalline schists having been in many instances originally igneous masses, and the graywackes volcanic ashes.

Prof. T. E. Bonney notes the occurrence among the Wealden rocks of England of a hard white sandstone consisting of grains of quartz cemented by secondary quartz "sometimes but not always in optical continuity with the original grains." Near this also occurs a greenish sandstone consisting of well rounded grains of quartz cemented by *chalcedonic* quartz, "the tiny crystals commonly growing outward from each sand grain like a fringe." "This is," he adds, "rare among the older rocks, though a case is mentioned by the late Prof. R. D. Irving in a cherty Potsdam sandstone from Wisconsin.

The Texas geological and scientific association, with head-quarters at Houston, issues a monthly bulletin, under the management of E. T. Dumble, secretary. In the August bulletin Mr. W. H. Streeruwitz describes some remains of old mines and furnaces in central Texas once worked by the Spaniards, which were abandoned because of the hostility of the Comanche Indians. These mines, however, were worked on a small scale, and they were easily suppressed by the natives.

The same number contains an excellent account of a heavy lubricating oil from the springs of Nacogdoches county, by professor Everhart of the University of Texas.

DR. C. A. WHITE, DESCRIBES A NEW GENERIC FORM of Cretaceous Astræidæ from Kaufman county, Texas, in the *Geological Magazine*, vol. v. p. 362, naming it Hindeastræa discoidea, in honor of Dr. G. Jennings Hinde.

PROF. C. H. GORDON, KEOKUK, IOWA, publishes a carefully studied section of the deep well lately drilled by J. C. Hubinger, at that city, and compares it with the section given by Prof. Calvin of the deep well at Washington, Iowa,* finding a general agreement; the distance between them is 63 miles. Both wells find a white sandstone just below the Devonian limestones, and Prof. Gordon follows Prof. Calvin in assigning it to the Niagara. It may, however, be the Oriskany sandstone which is well known in Ohio and Illinois at this horizon. A similar white sandstone was found at the same horizon in some deep wells at Albert Lea, Minnesota.

THE ANNUAL MEETING OF THE IOWA ASSOCIATION for scientific research was held at Des Moines, Sept. 5 and 6. The following geological papers were read:

On the folding of Carboniferous strata in south-western Iowa. PROF. J. E. TODD.

The fauna of the lower Coal Measures at Des Moines, Iowa. CHARLES R. KEYES.

The lineage of lake Agassiz. PROF. J. E. TODD.

Some additional observations on the Loess in and about Muscatine. PROF. M. F. WITTER.

The geology of Crowley's ridge, Arkansas. PROF. R. ELLSWORTH CALL.

On the glacial drift and Loess of a portion of the north-central basin of Iowa. CLEMENT L. WEBSTER.

Description of two new fossils from the Devonian of Iowa. CHARLES R. KEYES.

THE STATE GEOLOGIST OF ARKANSAS, PROF. J. C. BRANNER, has recently discharged an important duty to the State, and to the United States. He has reported to the Governor of the state that he considers a large percentage of the mining enterprises and stock companies organized in that state and professedly based on remunerative mining, to be without valid foundation. He is satisfied that some unscrupulous assayors have fostered the craze which has prevailed for nearly two years. Prof. Branner has quietly gathered evidence of this, and is well fortified in his course.

PROF. JAMES HALL IS RE-VISITING SOME of the celebrated fossil bearing localities in Indiana, Ohio and Illinois. He is closing up his great work on the paleontology of New York, at which he has been engaged for more than forty years, and will make large collections in the west for purposes of comparison

REV. PROFESSOR JOHN GMEINER, ST. PAUL, MINN., contributed

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*AMERICAN GEOLOGIST, vol. 1. p. 28.

to the late international scientific Congress of Catholics, in Paris, a resume of the doctrine of evolution, written in Latin. It is indicative of the enlightenment of the Catholic clergy on the important phases of modern science that this document, which in the main sustained the theory of evolution, excepting only some of the "grave errors" of Herbert Spencer, was favorably received and commended by the great assembly.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS—LONDON SESSION. The last session convened at London, September 17, and closed September 22. The positive results of the meeting are less numerous and less conspicuous than those of former sessions. This is on account of the nature of the later work of the Congress, which includes some questions which, on account of disagreement, had been, by common consent, postponed. Former sessions have put the approval of the Congress on many things concerning which there was greater, or even complete concord of opinion. The chief value of the session will be found to consist in the presentation of facts and the expression of views sometimes in lengthy memoirs of some of the principal geologists of the world on these unsettled questions of nomenclature. The full effect of these able communications could not be expected to appear at once and the conservative and wise recommendation of M. Capellini in the case of the Cambrian-Silurian-Taconic controversy that vote thereon should be deferred to the next session, will afford opportunity for those who are interested to study the subject fully in the light of these memoirs and discussions. In this sense the London meeting may be considered a successful one, and perhaps to be more memorable than any of the former.

The first day's session was devoted to the election of the Bureau of the Congress and the delivery by president Prestwich of his opening address which rehearsed the history of past meetings of the Congress and indicated the work that remained to be done. The members of the Bureau, as recommended by the Council, were elected as follows:

BUREAU DU CONGRES.

PRESIDENT D'HONNEUR:

T. H. Huxley.

ANCIENS PRESIDENTS:

G. Capellini, 1881. *E. Beyrich, 1883.*

PRESIDENT:

J. Prestwich.

VICE-PRESIDENTS:

Allemagne ..	K. von Zittel.	*Hongrie* ..	J. von Szabo.
Australie ..	F. Liversidge.	*Indes*	H. B. Medlicott.

Autriche	..	M. NEUMAYR.	*Italie*..	..	F. GIORDANO.
Belgique	..	G. DEWALQUE.	*Norwege*	..	H. REUSCH.
Canada	..	T. STERRY HUNT.	*Pays-Bas*	..	K. MARTIN.
Danemark	..	M. JOHNSTRUP.	*Portugal*	..	J. F. N. DELGADO.
Espagne	..	J. VILANOVA-Y-PIERA.	*Roumanie*	..	G. STEFANESCU.
Etats-Unis	..	P. FRAZER.	*Russie*	..	A. INOSTRANZEFF.
France	..	A. DE LAPPARENT.	*Suede*..	..	O. TORELL.
Grande Bretagne		W. T. BLANFORD, A. GEIKIE, T. McK. HUGHES.	*Suisse*..	..	E. RENEVIER,

SECRETAIRES GENERAUX:

J. W. Hulke. *W. Topley.*

SECRETAIRES:

C. BARROIS,	C. LE NEVE FOSTER,	A. RENARD,
C. FORNASINI,	C. GOTTSCHE,	G. H. WILLIAMS.

TRESORIER:

F. W. Rudler.

MEMBRES DU CONSEIL:

T. G. BONNEY,	W. HAUCHECORNE,	E. VON MOJSISOVICS,
A. BRIART,	A. HEIM,	S. NIKITIN,
E. COHEN,	J. HOOKER,	R. OWEN,
H. CREDNER,	A. ISSEL,	A. PILAR,
E. DUPONT,	J. W. JUDD,	F. VON RICHTHOFEN,
J. EVANS,	R. LEPSIUS,	T. SCHMIDT,
W. H. FLOWER,	C. LORY,	B. STUR,
A. GAUDRY,	A. MICHEL LEVY,	T. TSCHERNICHEFF,
J. GOSSELET,	T. MACFARLANE,	E. VAN DEN BRŒCK,
M. VON HANTKEN,	O. C. MARSH,	C. D. WALCOTT.
		J. S. NEWBERRY.

The second day opened with a discussion of the classification of the Cambrian-Silurian. Mr. Hicks remarked that as a known impartial pupil of Salter on one side, he was equally attached to the Cambridge school and the Geological survey. He had hence, sought for the truth in an independent manner. With Salter the upper Cambrian is the equivalent of the primordial of Barrande, and its terms are inferior to the rest of the Silurian, so that the primordial fauna is at the summit of the Cambrian. Mr. Hicks has recognized since that beds inferior to these are equally fossiliferous, and the summit of the Cambrian is the Tremadoc, characterized by the fauna of *Olenus*. Above the Tremadoc begins a new fauna with graptolites and *Asaphus*. This is the Lower Silurian. The Cambrian school, on the contrary, establishing the Cambrian on stratigraphic characters, extends this system up to the Llandovery, where there is a discordance. Such is the difficulty, and the term Ordovician, of Mr. Lapworth, comprising the Lower Silurian of one and the upper Cambrian of the other, is recommended as a term of conciliation involving the whole.

Mr. Marr rejected stratigraphic limitations, and would hold

them to paleontology. Three faunas are everywhere distinguished. If the term Ordovician is adopted for the middle fauna, at once the Silurian and the Cambrian are defined. As a general term Mr. Marr recommended *Barrandian* for these three stages.

Mr. Lapworth, who proposed the term Ordovician as a means of compromise between the two schools, referred the success of this term to its known correspondence with nature and with the truth. A table, drawn to a scale, of the geological formations of England shows the approximate equality of the primary, secondary and tertiary terranes. These divisions correspond to the principal divisions of life upon the globe, which are paleozoic, mesozoic and neozoic. Just as the mesozoic period is divisible into two so the paleozoic period contains two natural divisions, the protozoic (Cambrian, Ordovician, Silurian) and the deutozoic (old Red, Carboniferous and Permian.)

Mr. Walcott gave his observations on the stratigraphic succession of Cambrian faunas in North America. The Cambrian presents three divisions; the Lower Cambrian, characterized by a new fauna of *Olenellus*, containing 42 genera and 112 species, known only in Sweden, in Europe; the Middle Cambrian, characterized by *Paradoxides*; the Upper Cambrian, characterized by *Dikelocephalus* or *Olenus*. These Cambrian beds are covered by the Lower Silurian or Ordovician.

Mr. T. Sterry Hunt stated that the three divisions universally adopted are those of Silurian, Ordovician and Cambrian, and he supported the proposition of Mr. Lapworth, to group them under the term protozoic. As to the question of the Taconic he admitted that the Taconic of the state of New York contains the second fauna, as newly recognized by Mr. Walcott, but the Taconian is below the primordial fauna, or the Cambrian, and corresponds to the *Urschiefer*.

M. Torell proposed to apply the name Cambrian to the primordial fauna of Barrande and to the beds below, which are fossiliferous with *Olenellus*. A special name for the clastic lower beds would be convenient. He would preserve the names Lower Silurian and Upper Silurian for the beds above the Cambrian, rejecting the new term Ordovician.

M. Gosselet remarked that the three English terms correspond exactly to the three faunas of Barrande; the Cambrian has its own fauna; the Ordovician is more allied to the Silurian by its fauna. The Silurian cannot claim for a moment the same independence. He rejected the terms protozoic and deutozoic, because of the importance of the Devonian which has had too great a development in the Ardennes.

M. Dewalque supported the opinion given by M. Gosselet and was in favor of the three successive terms, Silurian, Cambrian and Taconic.

M. Kayser supported the grouping into three grand divisions.

Mr. Geikie said the grand divisions which were the result of the labor of Murchison were recognized throughout the world. These divisions, to the number of three, are concordant with those of Barrande. We can differ as to the limits of the subdivisions, questions of detail, but not upon the fact of the three divisions. He was opposed to the term Ordovician, as useless, and believed that the terms Cambrian, Lower Silurian (which has priority) and Upper Siluiran, already adopted in two continents, have the advantage of being sufficiently clear and known.

Mr. Blake believed that in addition to the three grand faunas, recognized by all, a fourth fauna appears—that of *Olenellus*,—the importance of which, at the base, would be equal to the preceding. He proposed the name *Monian* for this new system which would exist with different facies in England and Ireland.

M. de Lapparent was of the opinion that before reaching a decision on the part of the Congress, it was important to dispel all misunderstanding relative to the base of the Cambrian. The Cambrian would only be the equivalent of the term Ordovician if it is limited by fossiliferous distinctions. If the Cambrian be extended to the limit of the crystalline schists it would form a division as important as the two others.

M. Delgado, with M. Choffat, has indicated on the map of Portugal the three divisions already mentioned, but he has introduced, besides, a fourth term for the old clastic formations.

Mr. Hull thought that every change of nomenclature ought to be based on important considerations; now he did not see any that were pressing. The designation of Lower Silurian of Murchison has priority over Ordovician. It has the advantage of having been applied in all the work done on the continent. It cannot for that reason pass into synonymy.

M. Barrois remarked that the term Silurian does not lead to synonymy on the continent, and that it corresponds to the Ordovician and the Upper Siluvian. The term Cambrian would contain two divisions—the upper with *Paradoxides*, the lower generally azoic.

Mr. Gilbert held the question from a more general point of view. Boundaries are local questions; names are matters of indifference; comparisons, the importance of which is of the first order, increase in difficulty with the distances; the future will modify our ideas; before attempting systems of classification it is necessary to know the series in other parts of the world still unexplored.

M. Capellini concluded that the division under three term of the Cambrian and Silurian terranes appeared to unite the greater portion of the suffrages. Notwithstanding the general assent he judged it preferable to postpone the vote.

On the third day a similar discussion was had on the crystalline schists. Eight printed memoirs were presented. These served as basis for the discussion, which was participated in by Messrs. Lory, Mattirolo, Macfarlane, Issel, Heim, Hunt, Hicks, de Lapparent, Torell and MacPherson. One of the most important statements made was that by Torell who said that he distinguished in Sweden two granites, one eruptive and the other ancient and passing to gneiss. This ancient granite presents in the environs of Stockholm a remarkably globular structure. This structure, referred by several authors to a separation in a magma in fusion, had really a different cause. Gradual transitions have induced Torell to consider the globular rock as a re-cemented gneissic breccia, modified after the break by hydrothermal penetrations.

The fourth day was devoted to the limits and distinctions of the Tertiary and Quaternary. There was a strong opposition, led by M. Renevier, to the use of the term Quaternary. He considers it more properly as a sub-division of the Tertiary, and would replace it by the term Pleistocene. De Lapparent considered the appearance of man as an event so important, from a biological point of view, as to warrant the beginning of a new phase. M. Gaudry also thought the Quaternary should be separated from the Tertiary on account of the reign of man. M. Sacco mentioned seismic phenomena, added to those of a biological character, which favored the separation. Mr. Blanford agreed with Renevier. He regretted that the term had been adopted for the geological map of Europe. M. Gosselet saw a new argument in favor of the Quaternary in the great development of fluviatile phenomena, which characterize this epoch. Mr. John Evans thought that without assigning to the Quaternary as a division of time, absolutely the same value as to Tertiary as a convenient conventional term it would be useful to distinguish the epoch during which man has existed. De Lapparent considered that besides the appearance of man there were reasons strictly geological which characterized the Quaternary. Foraminifers and nummulites are not found in the Quaternary. Simple volcanic explosions succeed the great floods through fissures that marked the Tertiary; finally may be mentioned the remarkable increase of glaciers. M. Pilar believed in a convenient and useful classification which would co-ordinate with the facts. He considered the anthropozoic group therefore equal in value to the mesozoic or the paleozoic. Mr. Prestwich agreed with Gaudry and de Lapparent. The difficulty of finding a separation between the Quaternary and the Tertiary is found between other terranes. The small relative extent of the Quaternary is of no importance. That which dates history is great events. Now there was an event of the greatest importance in the Quater-

nary—the appearance of man, with all the existing fauna. In addition may be mentioned cosmic phenomena and an important change in climate. He adopts for the Quaternary epoch the term Pleistocene and makes it begin in England, with the base of the *Forest-bed.*

The fifth day was occupied with various matters—such as the choice of Philadelphia as the place of the next meeting, the presentation and explanation by M. Hauchecorne of the first sheet of the International geological map of Europe, the examination of rock specimens presented by M. Hull showing a remarkable double schistosity. The micaceous lamellæ are oriented in two principal directions, in accord with two distinct periods of metamorphism. A general discussion of the origin and ages of the crystalline schists was then revived, participated in by Messrs. Hunt, Gosselet, Blake, Claypole, Renevier, Heim, Delgado, de Lapparent, Lapworth and Callaway. M. Heim stated that the trunks of trees cited as being in the gneiss of Switzerland are not in the true gneiss, but in the intercalated beds in the pseudo-gneissic sericitic rocks. Also the Belemnites mentioned are in the schistose rocks, embracing albite, garnet, chlorite and mica.

On the last day the president announced the names of the provisional committee of Americans to arrange for the Philadelphia meeting, as follows: J. D. Dana, James Hall, J. S. Newberry, Persifor Frazer, G. K. Gilbert, T. Sterry Hunt, C. D. Walcott, and O. C. Marsh. Dr. P. Frazer said that the Congress having agreed to meet next in Philadelphia in 1891, he had been requested to explain the nature of the quite remarkable invitation which his fellow-citizens, through him, accorded the Congress. Two reasons were urged why the Congress should give Philadelphia the distinction of being its host. The first reason was that in 1891 the University of Pennsylvania would celebrate the 100th anniversary of the present organization. It was then intended to have *savants* from all parts of the world, upon some of whom would be conferred scholastic degrees. The University of Pennsylvania was among the five oldest universities on the continent of America and notwithstanding that it was already more liberally provided with buildings than any of the other universities save one, $3,000,000 was likely to be expended upon additional accommodation. The Provost of the University had authorized him to say that every facility and accommodation would be afforded members of that Congress. The centennial celebrations would not commence until September 23, so that at any previous time the buildings would be free for the use of the Congress. In 1891 too, about the time of their meeting, there would be an International Medical Congress at Washington. The chief reason, however, for inviting the Congress to Philadelphia was the fact that the

committee which first formed the Congress was called the "Foundation Committee of Philadelphia," and was so named in 1876 during the celebration of the centenary of America's independence. The chief officers of the city government, of the superior and common council, the judges of the several courts, the United States officers in Philadelphia, the presidents of the banks, the great railways and the great manufacturing concerns, the attorneys, business men, teachers, and all classes, in fact, had united in a cordial welcome. While he was not authorized to make specific declarations, he could say on his own responsibility that inasmuch as the principal officers of the three great railway systems, which might be called trans-continental as well as trans-oceanic, had joined in the invitation, there was no doubt that excursions would be arranged for the members to the Rocky mountains, the great lakes, the south-east coast, and to Canada. Moreover, it was probable that the cost of the voyage from Europe would be reduced one-half.

A new committee of uniformity of nomenclature, with extended duties, was created, with instructions to put itself into communication with the national committees and with scientific societies. This consists of the members of the old committee, with the addition of von Zittel in place of Renevier for Germany, de Castillo for Mexico and Merkelbusch for the Argentine Republic. The president is Capellini, and the secretary is Dewalque.

M. de Lapparent presented the report of the committee on the subject of voting. In order to avoid the inconvenience which might arise from the great numerical superiority of the members belonging to the country in which the Congress is held, the committee recommended that the votes should be decided in the following manner:—The votes of native members and the votes of the foreign members should be taken separately. If the votes of the two divisions were accordant, the result was to be accepted; but if they differed, the subject was to be considered immature and for settlement. Matters purely theoretical should not be voted upon by the congress. These recommendations were carried unanimously. M. de Lapparent then expressed his appreciation of the courtesy and respect for the individual which had been shown by the English members of the Congress. They had been in a sufficient majority to carry any proposition; but, instead of using their power, the London Congress had been signalized by the adoption of the foregoing rules for voting.

After adjournment excursions were made to North Wales, Yorkshire, the Isle of Wight and other places of geological interest, of which an explanatory handbook had been prepared by Mr. Topley.

PROF. J. W. SPENCER, HAS BEEN APPOINTED to the professorship of geology in the University of Georgia, at Athens, Ga. By the recent action of the trustees of the University separate chairs of geology and biology were created. The University of Georgia is nearly a hundred years old, and until about the time of the war was well equipped both as to its library and mineralogical and other collections. In recovering from the shock its energies were directed first to the departments of physics, chemistry and agriculture, all of which are among the best equipped in the country, and presided over by able professors. We congratulate the University that it has now seen its way to expand in these newly separated departments, and upon securing the services of Prof. Spencer. In former years its chair of chemistry, with geology attached, has been filled by Profs. Little and Jos. Le Conte.

THE COMMITTEE OF ORGANIZATION of the American Geological Society, announces through Prof. J. J. Stevenson, secretary, that 100 geologists have already been enrolled, and that the constitution therefore becomes operative. The first meeting will soon be called by the committee.

UNIVERSITY OF TEXAS, SCHOOL OF GEOLOGY. Professor Robert T. Hill, announces a School of Geology having both general and technical aims. Advanced students will be instructed in Geologic Technology, Bibliographic Methods, Petrography, Mineralogy, Paleontology and Applied Geology. These studies will be accompanied by field-work and excursions. The location is one of extraordinary interest, and this school ought to become the nucleus of great and useful geologic activity.

CORRECTION:

Page 180, under heading "SIR J. W. DAWSON" for the words——

"(*b.*) *igneous veins* (*chrysolite,*)" *etc.*

READ.

(b.) aqueous veins (chrysotil), etc.

H. Carvill Lewis

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PROF. HENRY CARVILL LEWIS AND HIS WORK IN GLACIAL GEOLOGY.

BY WARREN UPHAM.*

Henry Carvill Lewis, son of F. Mortimer Lewis and Emma Hulme (Carvill) Lewis, was born in Philadelphia on November 16th, 1853. He graduated at the University of Pennsylvania in 1873, with the highest honors in the classical course; after which he took a post-graduate course of three years in the natural sciences, receiving the M. A. degree in 1876. From 1879 to 1884 he was a volunteer member of the Geological Survey of Pennsylvania, investigating at first the surface geology of the southern part of the state, and afterward tracing the terminal moraine of the continental ice-sheet across northern Pennsylvania.

In 1880 he was elected to the professorship of mineralogy in the Academy of Natural Sciences, Philadelphia, and in 1883 to that of geology in Haverford College, both of which he held at the time of his death.

In 1882 he married Miss Julia C. Foulke, of Philadelphia, who, with a daughter, survives him and will endeavor to complete and publish portions of his unfinished work on the glacial drift in Great Britain.

From 1885 to 1887 professor Lewis was occupied during the winters in petrologic studies in Heidelberg with Prof. Rosenbusch, and during the summers in field-work on the glacial geology of England, Wales, Ireland, Switzerland, and northern

* For aid in the preparation of this article I am greatly indebted to Mrs. Lewis, now of London, to Mr. John F. Lewis, of Philadelphia, to Prof. G. F. Wright of Oberlin, and to the Geological Magazine, III, v., pp. 428-430, Sept., 1888.

Germany. Last winter and spring he spent in this country, and during that time visited the localities in the southern states where diamonds have been found, continuing his investigation of the origin of the diamond, on which he had read papers at the meetings of the British Association in 1886 and 1887, and was planning to present his matured results at the meeting of this year. Then it was his hope to extend his glacial studies to Norway and other parts of Europe.

On July 3rd, Prof. and Mrs. Lewis sailed from New York. In the latter part of the voyage he experienced symptoms of some illness, which developed into typhoid fever after he reached Manchester, England, where he died on the evening of July 21st, 1888, in his thirty-fifth year. The immediate cause of his illness was probably the contamination of the water supply of Philadelphia, where about a thousand cases of typhoid fever appeared at nearly the same time. Though professor Lewis had not reached the meridian of life, his work in mineralogy and geology, and especially his exploration of the glacial drift in the United States and in Great Britain, are of very high value.

Both his own family and that of Mrs. Lewis have held honored positions in the society, business development, and intellectual culture of Philadelphia through the past hundred years. His geologic bent was first shown almost in infancy, when on a visit to the country he was discovered busily digging in the gravel walk with a spoon, and, being asked why he did so, replied that he "wished to see what was underneath it." These dawning impulses were strengthened and encouraged by his maternal grandfather, Mr. Henry Carvill, who did much toward forming his later tastes. The first decided bias toward mineralogy and geology seems to have been given by the distinguished Dr. Isaac Lea who, when Carvill Lewis was twelve years old, gave him some specimens as the foundation of a collection, and urged him to persevere in his study of them. A year later the attraction in things scientific had developed so much that he and some of his playmates formed a scientific society, of which he continued a member until it disbanded in 1875. For several years after his graduation he divided his time almost equally between geology and astronomy, and some of his earlier papers note observations of the aurora and the Zodiacal light. His observations and discoveries in mineralogy and petrology, notably those relating to

the diamond and to the Archæan rocks, not less than those pertaining to the glacial drift which are reviewed in this article, clearly illustrate his spirit of earnest and independent thought, embodied in his chosen motto for work. "Truth for authority, not authority for truth."

He had a firm Christian faith—the form of worship to which he was attached being the Episcopal. With fine mental and physical powers, a wide range of scholarship, a happy, genial and enthusiastic temperament, rare perseverance and industry, and a lofty devotion to the interest not only of science but of mankind, his life seemed to promise the widest usefulness and honor. Upon his grave in Walmsley church-yard at Bolton, near Manchester, a design in flowers from a friend told the ruling element of his character: "He loved the truth." Besides the keen grief of kindred and intimate friends, the geologists of two continents mourn the loss of a most gifted and faithful fellow-worker, who indeed already had achieved a grand life-work in the few years allotted to him. He was a member of the American and British Associations; of the American Philosophical Society, the Academy of Natural Sciences, and the Franklin Institute, in Philadelphia; of the Geological Society of Liverpool; and a fellow of the Geological Societies of London and Germany.

Professor Lewis first became specially interested in the glacial drift and its terminal moraine during the latter part of the year 1880, when in company with Prof. G. F. Wright he studied the remarkable osars of Andover, Mass., the gravel of Trenton, N. J., containing palæolithic implements, the drift deposits of the vicinity of New Haven, Conn., under the guidance of professor Dana, and finally the terminal moraine in eastern Pennsylvania between the Delaware and Lehigh rivers. The following year professors Lewis and Wright traversed together the southern border of the drift through Pennsylvania from Belvidere on the Delaware west-north-westerly more than 200 miles across the ridges of the Alleghenies to Little Valley near Salamanca, N. Y., and thence south-westerly 130 miles to the line dividing Pennsylvania and Ohio, which it crosses about fifteen miles north of the Ohio river. The report of this survey of the terminal moraine was published in 1884, forming volume Z of the reports of progress of the Second Geological Survey of Pennsylvania.

With the similar exploration of other portions of this great moraine done a few years earlier by Prof. Chamberlin in Wisconsin, Profs. Cook and Smock in New Jersey, and the present writer in Long Island, thence eastward to Nantucket, and Cape Cod, and also in Minnesota, it completed the demonstration of the formation of the North American drift by the agency of land-ice.

The observations of the moraine in Pennsylvania, detailed in this volume, are summarized by Prof. Lewis as follows: "The line separating the glaciated from the non-glaciated regions is defined by a remarkable accumulation of unstratified drift material and boulders, which, heaped up into irregular hills and hollows over a strip of ground nearly a mile in width, forms a continuous line of drift hills (more or less marked) extending completely across the state. These hills vary in hight from a few feet up to 100 or 200 feet; and while in some places they are marked merely by an unusual collection of large transported boulders, at other places an immense accumulation forms a noteworthy feature of the landscape. When typically developed this accumulation is characterized by peculiar contours of its own—a series of *hummocks*, or low conical hills, alternate short straight ridges, and inclosed shallow basin-shaped depressions, which like inverted *hummocks* in shape are known as *kettle holes*. Large boulders are scattered over the surface; and the unstratified *till* which composes the deposit is filled with glacier-scratched boulders and fragments of all sizes and shapes."

From its lowest point in Pennsylvania, where it crosses the Delaware, 250 feet above the sea level, this terminal moraine extends indiscriminately across hills, mountains and valleys, rising over 2,000 feet above the sea in crossing the Alleghenies and attaining the maximum of 2,580 feet on the high table-land farther west, being there "finely shown at an elevation higher than anywhere else in the United States."

Preliminary outlines of professor Lewis' work on the glacial drift of England, Wales and Ireland are given by his papers in the reports of the British Association for 1886 and 1887, and the first of these also appeared in the American Naturalist for November, and the American Journal of Science for December, 1886. Their most important new contribution to knowledge consists in the recognition of the terminal moraines formed by

the British ice-sheets, which Lewis traced across southern Ireland from Tralee on the west to the Wicklow mountains and Bray Head south-east of Dublin; through the western, southern and south-eastern portions of Wales; northward by Manchester and along the Pennine Chain to the south-east edge of Westmoreland, thence south-east to York and again northward nearly to the mouth of the Tees, and thence south-eastward along the high coast of the North Sea to Flamborough Head and the mouth of the Humber. It is a just cause for national pride that two geologists of the United States, Lewis in Great Britain in 1886, and Salisbury* the next year in Germany, have been the first to discover the terminal moraines of the ice-sheets of Europe. Like the great moraines of the interior of the United States, those of both England and Germany lie far north of the southern limit of the drift.

Another very important announcement by Prof. Lewis relates to the marine shells, mostly in fragments and often worn and striated, found in morainic deposits and associated kames 1,100 to 1,350 feet above the sea on Three Rock mountain near Dublin, on Moel Tryfan in northern Wales, and near Macclesfield in Cheshire, which have been generally considered by British geologists as proof of marine submergence to the depth of at least 1,350 feet. These shells and fragments of shells, as Lewis has shown, were transported to their present position by the currents of the confluent ice-sheet which flowed southward from Scotland and northern Ireland, passing over the bottom of the Irish sea, there plowing up its marine deposits and shells, and carrying them upward as glacial drift to these elevations, so that they afford no testimony of the former subsidence of the land. The ample descriptions of the shelly drift of these and other localities of high level, and of the lowlands of Cheshire and Lancashire, recorded by English geologists,† agree perfectly with the explanation given by Lewis, which indeed had been before suggested, so long ago as in 1874, by Belt and Goodchild.‡

*American Journal of Science, III, xxxv, pp. 401-407; May, 1888.

†Quarterly Journal of the Geological Society, London, vol. xxx, 1874, pp. 27-42; xxxiv, 1878, pp. 383-397; xxxvi, 1880, pp. 351-5; xxxvii, 1881, pp. 351-369; and xliii, 1887, pp. 73-120; also, Geological Magazine, II, i, 1874, pp. 193-197.

‡Nature, vol. x, pp. 25, 26; Geol. Mag., II, i, pp. 496-510. A similar

This removes one of the most perplexing questions which glacialists have encountered, for nowhere else in the British Isles is there proof of any such submergence during or since the glacial period, the maximum known being 510 feet near Airdrie in Lanarkshire, Scotland.† At the same time the submergence on the southern coast of England was only from 10 to 60 feet,‡ while no traces of raised beaches or of pleistocene marine formations above the present sea level are found in the Orkney and Shetland islands.‖ The work and writings of professor Lewis emphasize the principle that glacially transported marine shells and fragments of shells, which occur in both the till or boulder-clay and the modified drift in various parts of Great Britain, are not to be confounded with shells imbedded where they were living or in raised beaches, for only these prove the former presence of the sea.

The drift deposits of England south of the terminal moraines traced by Lewis were regarded by him as due to floating ice upon a great fresh-water lake,held on the north by the barrier of the ice-sheet which covered Scotland, northern England, and the area of the North sea, and on the south-east by a land barrier where the strait of Dover has since been eroded. Under this view he attributed the formation of the Chalky boulder-clay in East Anglia and of the Purple and Hessle boulder-clays in Lincolnshire and much of Yorkshire to lacustrine deposition, and believed that there was only one advance and recession of the ice-sheet. But shortly after the British Association meeting in 1887 his observations on Frankley hill in Worcestershire and thence westward§ led him to accept the conclusion, so thoroughly worked out by other glacialists both in America and Great Britain, that there were two principal epochs of glaciation, divided by an interglacial epoch when the ice-sheet was mostly melted away. There can be little doubt that the continuation of Lewis' study of the drift in England, if he had lived, would

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opinion was held fifty years ago by Mr. James Smith (Researches in Newer Pliocene and Post-Tertiary Geology, pp. 11 and 16), though he attributed the drift to debacles instead of glaciation.

† Quart. Journ. Geol. Soc., vol. vi, 1850, pp. 386-8; xxi, 1865, pp. 219-221

‡ Quart. Journ. Geol. Soc., xxxiv, 1878, pp. 454-7, xxxix, 1883, p. 54; and Geol. Mag., II, ii, 1875, p. 229; II, vi, 1879, pp. 166-172.

‖ Quart. Journ. Geol. Soc., xxxv, 1879, p. 810; xxxvi, 1880, p. 663.

§ Geol. Mag., III, iv, pp. 515-517, Nov., 1887; v, p. 480, Sept., 1888.

have soon convinced him of the correctness of the opinions of Searles V. Wood, Jun., Mr. Skertchly, and James Geikie,* that land-ice during the earlier glacial epoch overspread all the area of the Chalky boulder-clay, extending south to the Thames. Small portions of northern England, however, escaped glaciation both then and during the later cold epoch when the terminal moraines mapped by Lewis were accumulated; and these tracts of the high moorlands in eastern Yorkshire and of the eastern flank of the Pennine Chain† are similar to the driftless area of south-western Wisconsin.

Comparison of the drift in the United States and Great Britain enabled professor Lewis to refer the British modified drift, both that often intercalated between deposits of till and that spread upon the surface in knolly and hilly kames and more evenly in plains and along valleys, to deposition from streams supplied by the glacial melting, the material being washed out of the ice-sheet. These beds, however, are to be carefully distinguished from those of interglacial and post-glacial age. It is greatly to be regretted that this sagacious observer was not spared for the fulfillment of his plan of yet more extended study of European glacial deposits in the light of his wide knowledge of the terminal moraine and other drift formations in this country.

The following is a nearly complete list of professor Lewis' published papers:—

"Report on the Terminal Moraine in Pennsylvania and western New York. Illustrated by a map of Pennsylvania showing the glaciated region, eighteen photographic views of the moraine, and thirty-two page-plate maps and sections," pp. 299. Second Geol. Sur. of Pa. Report of Progress, Z. 1884.

"On a New Substance resembling Dopplerite from a Peat Bog at Scranton." Proc. Amer. Phil. Soc., vol. xx, 1883, pp. 112-117. Proc. Acad. Nat. Sci., Phila., 1882, pp. 52, 53. An. Rep., Geol. Sur. of Pa. for 1885, pp. 647-656.

"Note on the Aurora of April 16-17, 1882." Proc. Amer. Phil. Soc., xx, pp. 283-291.

"Map of the Terminal Moraine." Id., xx, pp. 662-664.

"A great Trap Dyke across south-eastern Pennsylvania." Id., xxii, 1885, pp. 438-456, with map. Proc. Amer. Assoc. for Adv. of Sci., Phila., vol. xxxiii, 1884, pp. 402, 3.

* Quart. Journ. Geol. Soc., xxxvi, 1880, pp. 463-500; Great Ice Age, second ed., pp. 350-365.

† A. Geikie's Text Book of Geology, p. 903; Quart. Journ. Geol. Soc., xxxii, 1876, pp. 184-190.

"On Strontianite and Associated Minerals in Mifflin Co." [Pa.] Proc. Acad. Nat. Sci., Phila., 1876, pp. 11, 12. This seems to have been Mr. Lewis' earliest scientific publication.

In the "Proceedings of the Mineralogical and Geological Section of the Academy of Natural Sciences of Philadelphia, 1877-1879," contained in the volume of the year 1880, Mr. Lewis presented twenty-nine communications of which the more extended are:

"The Optical Characters of some Micas," pp. 244-251.

"On Siderophyllite—a new Mineral," 254,5.

"The Surface Geology of Philadelphia and Vicinity," 258-272.

"On the Bryn Mawr Gravel," 277,8.

"The Iron Ores and Lignite of the Montgomery Co. Valley," 282-291.

"On a new Fucoidal Plant from the Trias," 293,4.

"The Trenton Gravel and its Relation to the Antiquity of Man," 296-309.

"On Philadelphite (Sp. Nov.)," 313-328.

The Proceedings of the Academy of Natural Sciences for the year 1882 contain fifteen communications from Prof. Lewis, including:—

"Pseudomorphs of Serpentine after Dolomite," pp. 36-38.

"On a new Ore of Antimony," 38-40.

"An American Locality for Helvite," 100-102.

"Some Enclosures in Muscovite," 311-315.

In the volume for 1883 are eight communications, including:—

"On a supposed Human Implement from the Gravel at Philadelphia," 40-43.

"Crystallized Serpentine from Delaware," 72 74.

From the later volumes all of Prof. Lewis' papers are here noted:

"A Phosphorescent Variety of Limestone." Proc. Acad. Nat. Sci., 1884, pp. 10-12. American Naturalist, vol. xvi, 1882, pp. 687,8.

"Volcanic Dust from Krakatoa." Proc. Acad. Nat. Sci., 1884, pp. 185,6.

"Erythrite, Genthite and Cuprite from near Philadelphia," id., 1885, pp. 120-122.

"Marginal Kames," id., 1885, pp. 157-173, with map. This is the full text of a paper read before the British Association for the Advancement of Science, Montreal, Aug. 29th, 1884.

Abstract in Geol. Mag., III, i, 1884, pp. 565,6.

"Diamonds in Meteorites." Proc. Acad. Nat. Sci., 1888, pp. 81, 82.

"The Great Ice Age in Pennsylvania." Journal of the Franklin Institute, third series, vol. lxxxv, 1883, pp. 287-307.

"The Geology of Philadelphia," id., same vol., pp. 359-374 and 422-427.

"The Antiquity and Origin of the Trenton Gravel." In Dr. C. C. Abbott's "Primitive Industry," Salem, Mass., 1881, pp. 521, 551.

"Note on the Zodiacal Light." Amer. Journ. of Sci., third series, vol. xx, pp. 437-445, with plate; Dec. 1880. Proc. Amer. Assoc., Boston, vol. xxix, 1880, pp. 241-243.

"Supposed Glaciation in Pennsylvania south of the Terminal Moraine." Amer. Journ. Sci., third series, vol. xxviii, pp. 276-285, with map; Oct., 1884.

"An interesting Mineral [Cacoclasite] from Canada." American Naturalist, vol. xviii, pp. 416-417; April, 1884. During three years, 1882-84, Prof. Lewis was editor of the department of Mineralogy in the American Naturalist.

"The Aurora and Zodiacal Light of May 2, 1877." Proc. Amer. Assoc. for Adv. of Sci., Boston, vol. xxix, 1880, pp. 243-246.

"The Iron Ores of the Brandon Period," id., xxix, 1880, pp. 427,8.

"The Antiquity of Man in Eastern America, geologically considered," id., xxix, 1880, pp. 706-709.

"The Great Terminal Moraine across Pennsylvania," id., Montreal, vol. xxxi, 1882, pp. 389-398, with map. Science, vol. ii, pp. 163-167, with map; Aug. 10, 1883.

"The Direction of Glaciation as ascertained by the Form of the Striæ," Report of the British Assoc. for Adv. of Sci., Aberdeen, 1885, pp. 1019-20.

"Some Examples of Pressure-Fluxion in Pennsylvania," id., pp. 1029-30.

"Comparative Studies upon the Glaciation of North America, Great Britain, and Ireland," id., Birmingham, 1886, pp. 632-635. Geol. Mag., III, iv, pp. 28-32; Jan. 1887. Nature, vol. xxxv, pp. 89-91; Nov., 25, 1886. American Naturalist, vol. xx, pp. 919-925; Nov., 1886. Amer. Journ. Sci. third series, vol. xxxii, pp. 433-438; Dec., 1886.

"On a Diamantiferous Peridotite and the Genesis of the Diamond." Rep. Brit. Assoc., Birmingham, 1886, pp. 667,8. Geol. Mag., III, iv, pp. 22-24. Science, vol. viii, pp. 345-7; Oct. 15, 1886.

"The Terminal Moraines of the Great Glaciers of England." Rep. Brit. Assoc., Manchester, 1887, pp. 691,2. Nature, vol. xxxvi, p. 573; Oct. 13, 1887. Amer. Journ. Sci., third series, vol. xxxiv, pp. 402,3; Nov., 1887.

"On some important Extra-Morainic Lakes in Central England, North America, and elsewhere, during the Period of Maximum Glaciation, and on the Origin of Extra-Morainic Boulder-clay." Rep. Brit. Assoc., Manchester, 1887, pp. 692,3. Geol. Mag., III, iv, pp. 515-517; Nov. 1887. Nature, xxxvi, p. 573.

"The Matrix of the Diamond." Rep. Brit. Assoc., Manchester, 1887, pp. 720,1. Geol. Mag., III, v, pp. 129-131; March, 1888. Nature, xxxvi, p. 571.

"On the Terminal Moraine near Manchester." Rep. Brit. Assoc., Manchester, 1887, pp. 724,5.

"Accounts of some So-called 'Spiritualistic' Seances." Proceedings of the Society for Psychical Research, London, Part xi, 1887, pp. 338-380.

Some of professor Lewis' manuscripts, left in a nearly finished condition, are being edited by his friend, Dr. George H. Williams, of the Johns Hopkins University.

According to Dr. G. M. Dawson a great confluent ice-man has occupied the region in British Columbia between the Coast mountains and the Gold and Rocky mountain ranges; this extended into Idaho and Washington territories.

THE ETHICAL FUNCTIONS OF SCIENTIFIC STUDY.

BY PRES. T. C. CHAMBERLIN.

[An address delivered at the annual commencement of the University of Michigan, June 28, 1888.]

ABOVE all material acquisitions, above all intellectual attainments, above even the refinements of culture, in the esteem and endeavor of true educators, rises the moral exaltation of an individual or of a people. Whatever contributes to intellectual attainment rises in regard above material acquisition; whatever contributes to the refinements of thought rises above mere intellectual vigor; whatever contributes to moral elevation rises above all these. Whatever, therefore enters into the curricula of our institutions of learning, invites judicial inquiry respecting its ethical character, tendencies and effects. I sympathize with those who esteem a devout and reverent spirit as loftier than all these, crowning them all; but that lies beyond and above our present theme.

It is not our habit to attach the idea of the moral to what we are accustomed to designate intellectual processes. We are wont to permit ourselves to regard certain mental activities as indifferent in moral character. Some activities do indeed betray an ethical nature less obtrusively than others. Unquestionably the feelings and the choices bring more distinctly into consideration than do the processes of the intellect the question whether their action is right and wholesome or indifferent or evil. Nevertheless it is here affirmed that a moral character attaches to our thinking as well as to our feeling and to our action. "As a man thinketh * * so is he." The swerving of the mind from absolute rectitude in any of its activities falls under ethical condemnation. Falsity in intellectual action is intellectual immorality. Narrow and loose habits of thought, prejudiced attitudes towards evidence, bias from previous opinions and feelings, shallowness and superficiality in observation, and carelessness in reasoning are appropriate subjects of moral reproof. If, in the sharpest analysis, these are not purely intellectual, they are at least concomitants of our studies, and I therefore feel justified in designating them intellectual immoralities. If the purist in metaphysical distinctions shall insist that the ethical character resides in the emotional and volitional

element that necessarily accompanies intellectual action, I shall make no issue with him. It is the actual concrete action of the mind and not its ultimate abstract analysis that concerns us in this discussion. The full sphere of moral completeness is only attained when the trinity, to think right, to feel right, and to do right, are joined in individual perfection to form an ethical unity.

I crave your indulgence, therefore, in the use of the terms moral and ethical in a sufficiently broad sense to embrace all falsity of mental action and all harmful processes of thought.

If you strike hands with me in this fundamental view, you cannot fail also to join in the affirmation that every intellectual activity that enters into our processes of education is a fit subject of inquiry respecting its inherent moral character and its ethical tendencies and results.

We shall plunge at once, however, into misunderstandings unless we agree upon a special meaning also for the phrase, scientific study. In common speech, science has come to signify merely physical or natural science. Let us set aside this common but narrow sense, and adopt the true and full meaning which embraces all specific systematized knowledge; not less knowledge of the mind and the humanities than of matter and its creatures. The objects of nature present tangible subjects of inquiry, governed by fixed and relatively simple laws, while mind and its products present profound intricacies, intangible factors, and the mystery of volition. The former have on this account offered the easier and thus far the more fruitful field for the development of demonstrative knowledge, and hence the science of things physical and things natural sprang up earlier and grew more rapidly than the science of things mental and things artificial. It has therefore happened, not strangely, that the term science has come to be monopolized in common speech by knowledge of the physical world, ignoring the sciences of mind, of language, of civic institutions, of morals and of religions. But, unless the element of volition vitiates the reign of law, the systematic study of language, of history, of civic institutions and of the mind itself, is, or at least should be as truly scientific, in process and in product, as the study of earth or of air, of tree or of beast. As a disciple of "the gospel of dirt," I may, without suspicion of bias, urge that the simpler and lower

shall not monopolize the insignia of superior knowledge, to the exclusion of the higher and more intimately human. By science, therefore, let us understand not merely physical and natural science, but *all* specific and systematic knowledge.

Even if the element of volition removes the products of mind from the strict domination of unchangeable law, it may be none the less profitable to subject them to the sharp discriminations, the severe questionings and the rigid inductions that mark scientific methods of study. It is not necessary to the scientific process to assume the rigid reign of law; on the contrary, the reign of law is rather an induction of science than its postulate.

There is another necessary discrimination, a distinction between *scientific study* and *the study of science.* By scientific study let us understand, not the subject matter, but the character of the study. Let it signify the exercise of those mental activities by which truth is discerned and brought into orderly array in all its relationships. The study *of* science may be a mere memorizing of the products of scientific study, having in itself no more of the nature and spirit of scientific inquiry than the memorizing of John Gilpin, or the mastering of the figures of a quadrille. To learn the results and the dicta of science involves an intellectual process essentially the same as learning the products of the imagination or the prices of commodities. In our university classes in science one student follows independently the processes by which the fabric of science was constructed. This is scientific study. Another student, ignoring these, leaps across the original processes to the final result, which alone he gathers into his comprehension and holds by an enforced action of the memory. This is knowledge gathering, not scientific inquiry. The former is a scientific student in the true sense; the latter is, at best, not more than a student *of* science. Let us agree therefore, that, for the time at least, scientific study shall mean to us the study employed in the development of science, which the true scientific student imitates in the *seminar*, the laboratory, and the field.

The distinction between scientific study and the study of science is much the same as that between creative scholarship and acquisitive scholarship; between modern research and ancient erudition.

If now we are agreed that a moral character attaches to our

thinking as well as to our feeling and our willing; and if we are further agreed that scientific study shall mean the intellectual processes that enter into the development of science, and that it shall not mean the mere conning of knowledge; and if we further agree that the physical sciences are only the more early ripened fruits of a broad intellectual field now whitening to the harvest, we may with less fear of parting company later, turn to the inquiry, what are the ethical aspects of scientific study, and what is its practical, though it be slow and distant, influence on some of the dominant evils of our times?

The essence of my argument will be this: scientific inquiry involves certain fundamental habits of thought. When these become fixed in the intellectual nature, they form a permanent disposition which influences all the individual's subsequent action. That disposition displaces certain other dispositions from which spring some of the prevalent evils of our day, and by so displacing them, it radically affects the moral welfare of our people. It forestalls an immoral issue by wholesome and preventive antecedent action. Its influence is not so much curative as preventive. The earlier physicians concerned themselves with disease and its remedies; the later concern themselves with health and its conditions. To secure the universal remedy was the ancient endeavor; to secure universal health is the true endeavor. To *correct* harmful action is not so much an object of effort as to *prevent* it. Moral endeavor should be turned not so much to the remedial as to the preventive.

As educators we are coming to realize, what the great captains long since learned, that entrenched positions are often to be flanked rather than assaulted directly. We may waste our forces and crown the enemy with triumph by direct onslaught, when we might, by more wisely directed efforts, ourselves bear away the fruits of victory. Direct moral denunciation and specific legislative prohibition have their important functions, but many great evils can best be eliminated by displacing immoral tendencies by wholesome dispositions, and by forestalling wrong action by inducing a dominant tendency to right action.

1. Let us first note certain characteristics of scientific study, and then turn to their application.

In scientific study, or, as I prefer to phrase it, in creative scholarship, the truth is the single end sought; all yields to that. The truth is supreme, not only in the vague mystical sense in which that expression has come to be a platitude, but in a special, definite, concrete sense. Facts and the immediate and necessary inductions from facts displace all pre-conceptions, all deductions from general principles, all favorite theories. Previous mental constructions are bowled over as childish play-structures by facts as they come rolling into the mind. The dearest doctrines, the most fascinating hypothesis, the most cherished creations of the reason and of the imagination perish from a mind thoroughly inspired with the scientific spirit in the presence of incompatible facts. Previous intellectual affections are crushed without hesitation and without remorse. Facts are placed before reasonings and before ideals, even though the reasonings and the ideals be more beautiful, be seemingly more lofty, be seemingly better, be seemingly truer. The seemingly absurd and the seemingly impossible are sometimes true. The scientific disposition is to accept facts upon evidence, however absurd they may appear to our pre-conceptions.

2. This supreme love of truth is furthermore active and instinctive, not a mere passive, receptive love of truth when truth is forced in upon the mind. It arises in its own strength and in its own inspiration and goes forth to search for specific, positive, demonstrative truth. It is moved by a controlling thirst for truth, the naked, the innermost, the vital, the fundamental truth.

3. Moreover the activities of the ideal scientific mind do not go forth merely as an affection and as an enthusiasm, but also as a scrutinizing, questioning agency whose hatred of falsity is as great as its love of truth. Its first action is to demand the credentials of whatever offers itself for acceptance; if it be an observation, it is to be rigorously verified; if it be an induction, its validity is to be unsparingly probed; if it be a classification, its basis and its collocations are to be questioned; if it be a mental structure, the strength of every part is to be put to trial. If possible, the crucial tests of experimentation are to be brought to bear upon it. In the scientific structure every beam is to be tested, every joint is to be put to trial. The edifice is to be built on knowledge and not on faith; on proof and not on

opinion. Conjectures, assertions, opinions, current impressions, pre-conceived notions, accepted doctrines, all alike are pushed aside to give free scope to untrammelled inductions from carefully sifted evidence.

4. It is a further canon of creative scholarship that conclusions are to be withheld when evidence is insufficient. It is as important to withhold assent, when the proof is inadequate, as to yield assent when it is ample. The measure of acceptance in any case is precisely the measure of the evidence. In this regard the law of scholarship stands opposed to the law of action. Given two courses to be pursued upon which insufficient evidence sheds an uncertain light, the man of action, when action is required, will choose that course towards which the balance of evidence, however slight, inclines. The scholar, when scholarship is required, merely balances the evidence, determines the measure and direction of preponderance, and there rests his judgment. If 51 per cent. of such probabilities as there may be indicate that the one course is the true one, against 49 per cent. indicative that the other course is the right one, even though the total of indications be small, the law of action, when action is imminent, demands that the former should be chosen, and faith summoned to take the place of knowledge. But the law of scholarship demands that the evidence be simply evaluated as 51 to 49, and the judgment there rested with no conclusion and but slight tendency to belief, since 51 per cent. of such evidence as there is is far less than what there should be to justify an induction. The habit of withholding conclusions is therefore an essential factor in the trustworthy determination of knowledge.

5. A fifth and supreme characteristic of typical scientific study, is a judicial attitude of the mind. The supreme endeavor is to present a disposition of absolute fairness toward all evidence and all inductions. Belief and unbelief are alike unto it. Whatever evidence demands, that it accepts; whichever way the balance of evidence inclines, to that it leans. There is no resistance to the leadings of evidence; there is no pressing of evidence to give it greater or less than its intrinsic weight. All lines of inquiry are pursued with equal avidity; all phenomena are welcomed with equal cordiality. The mind opens itself on all sides to all avenues of truth with equal impartiality.

This is indeed an ideal attitude. No one fully attains to it, no one is entirely free from the influence of predisposition. Complete impartiality is divine, not human. He who claims absolute freedom from bias deceives himself. He who does not recognize the prejudices of his own mind becomes to that extent untrustworthy. The nearest approach to complete equipoise is attained when the mind, by earnest endeavor, frees itself to the utmost from the conditións that predispose it to partiality and constrains itself to the utmost to act with judicial fairness, and then, having done all to be impartial, measures up, so far as it may, its own bias and discounts its conclusions accordingly. It requires an almost preternatural self-inspection and a lofty moral courage to systematically discount one's own work for one's own persistent errors. It crucifies the natural pride to turn upon one's self the same severe probing for weakness that one applies to others.

The astronomers, geodesists and other precise observers have set us an example worthy of imitation in all departments of thought. It is their practice to ascertain by careful tests their habitual errors, and then to correct their results as conscientiously for their own personal defects as for the systematic errors of their instruments. This application of the personal equation should be extended beyond the field of observation and applied to all impressions, inferences, interpretations, inductions and opinions. It is indeed less easy to determine the personal error in these more recondite and complex processes of the mind, but the effect is none the less wholesome, none the less important to trustworthy results.

These are some of the dominant traits of mind that mark creative scholarship: to love the truth supremely, to seek the truth assiduously, to scrutinize evidence rigorously, to withhold judgment when evidence is insufficient, to look upon all sides equally, to judge with impartiality, and to make conscientious corrections for personal bias.

I have sketched these qualities as they are involved in pioneer research, but they are, or should be, equally involved in the training of the university student whose work may be but *quasi*-original. The school work may be only secondary or imitative research, but it may and should have in itself all the essential qualities of original investigation. The minor prob-

lems, the tests and the determinations of the student in the laboratory, the field, and the *seminar* may and should involve the same mental and moral characteristics as the more weighty work of the true discoverer. The scientific child in training should foreshadow the scientific man in creative work.

The continuous exercise of the mind during its formative stages in these sterling activities and in these scrupulous attitudes, and the development of corresponding habits of mental action have a direct bearing upon two of the great sources from whence spring reprehensible action, namely, defective and warped thinking and deficient regard for strict truth. These are not the only sources of blameworthy action, and the intellectual training under consideration is not the only remedy. The whole field of wrong-doing is not before us for consideration either in cause or cure. It is my effort only to point out the hygienic and preventive agency of a special phase of intellectual training. Let me not be understood as advocating a panacea.

A much larger percentage of reprehensible action springs from defective perception and interpretation than we are wont to realize. While this is true of those graver misdeeds that rank as crimes, it is much more widely true of those blameworthy actions which are not under the restraint of law or the forms of society. The "misunderstandings" that lead to broils and end in the crack of pistols are indeed *misunderstandings* in a large percentage of cases, and would never occur, even with the belligerent dispositions that prompt them, if clearer perceptions and truer interpretations replaced the dull apprehension and the twisted mental action that go before the passion and give it occasion. In a careful analysis of criminal cases it will be found of many, I think, that at some point in their history defective and distorted perception and interpretation constituted determining factors, and that had these been replaced by more complete and accurate understanding, the issue would have been reversed. I am far from maintaining that defective intelligence is the supreme factor in misdeeds. Morality must be advanced by other appliances than superior intellectual training. It is something to us, however, if this yields an important contribution to the exaltation of morals.

But the discussion of criminality is apart from my purpose. This is the weakest aspect of my subject. However beneficent

investigative study may be, the ignorant criminal classes are the most remote from its influence and the last to be reached by it. Law and public opinion must be chiefly relied upon to restrain these gross and criminal expressions of immorality.

Law and public opinion work at this lower end of the ethical series, while intellectual and ethical education work at the upper and initial end. Law and public opinion attack immorality in its results; intellectual and ethical education attack it in its sources. Law and public opinion deal with immorality in its last stages when it has developed itself into tangible acts. Intellectual and ethical training deal with it in its origin, in its initial possibilities; indeed they deal with *potential immorality* before it becomes immoral. Law and public opinion are restricttive, repressive, remedial. Ethically intellectual education is anticipatory and preventive. Law and public opinion, dealing with the tangible and demonstrative, are tangible and demonstrative in their effects, and hence have largely engrossed the attention of moralists and philanthropists. Ethically intellectual training, dealing with potential immoralities before they become actual immoralities, is intangible and undemonstrative in its effects, and has failed to command the full recognition which it merits.

These contrasted methods of attack are well illustrated in a prevalent evil which is being rapidly undermined by the spread of the spirit of creative scholarship. I refer to pugilism, physical and intellectual. There is a physical pugilism and there is an intellectual pugilism, with all gradations between. Law and public opinion have attacked effectively its grosser tangible expressions, but have scarcely reached beyond its physical aspects. From a primitive state in which no restrictions whatever were placed upon personal encounter, with or without weapons, public opinion, followed by law, gradually imposed restrictions until encounter with weapons came to be a crime and, at length, encounter without weapons, a misdemeanor. They have thus covered the field of the more physical and tangible. They have even advanced an important step further and forbidden personal attack in speech and in print of certain kinds and degrees. But though law and public opinion have entered upon this great field they have scarcely made themselves felt in it, and there remains a marked contrast between the prevalence of physical

pugilism and the prevalence of intellectual pugilism. Physical pugilism has been banished to the lower classes, but intellectual pugilism pervades the press, the pulpit, the platform, and the private walks of life. Personal encounter with the fists is under the ban of law and public opinion; but personal encounter with the tongue and the pen finds expression in levels where the other is unknown. To strike with the fist is beyond all thought in the better grades of society; to strike with the tongue grossly lies also under reproach, but to strike with the tongue adroitly too often escapes condemnation not only but even calls forth admiration. The morality of the fist is a full century in advance of the morality of the tongue. Literal John Sullivanism is under contempt among all cultivated people, but intellectual John Sullivanism, if sufficiently skillful, finds many an admirer in the galleries that look down upon legislative halls, in many a cushioned pew, even though bathed in "dim religious light." To thrash a ruffian has ceased to be an approved method of moral reform, but to thrash a congregation, a party, or a society, is still in common, if not in good practice.

If we rise a grade higher, we find widely, if not universally, prevalent attack in thought which does not find expression even in words; a spirit of pugilism unexpressed in tangible form but scarcely the less pervasive and mischievous.

Into this realm of the immoral, the concealed, the intangible immoral law can make no advance, and public opinion is relatively impotent. The remedy must come from the opposite source. The polemic element in the mental constitution, the relic of savage contests and still more ancient beastly battles, is to be eradicated by working at the fountains of thought and of feeling and by training the fundamental intellectual and ethical activities. The polemic habit in thought and in feeling has held sway through all the earlier ages of mind development and still holds wide dominance in the domains of opinion and belief. It has in some measure been banished from the domain of precise thought and from the more scientific and scholarly circles. Nevertheless some of our so-called scientific discussions have been altogether worthy to be ranked with the disputations of the middle ages. But the leaven of the spirit of impartial inquiry, of supreme devotion to the unqualified truth are rapidly banishing personal disputations and the contentious war of

opinion and substituting therefor judicial inquiry and impartial presentation.

There is an important aspect of personal morals which is destined to feel the force of the spirit of impartial inquiry, of discriminating perception, of reserved judgment and of strict regard for truth, which characterize scientific study. If I were called upon to name the greatest evil of our times, above the grade of the grossly criminal, that evil which brings the most poignant suffering to the most sensitive souls, that evil from which all suffer, and that sin of which all are guilty, I think I should name *misconstruction of personal actions and motives*, embracing in its train false interpretations, libelous thoughts, issuing in libelous words and stretching on down through its gradations of guiltiness until it reaches the lowest, most cowardly, most heinous, blackest of crimes, the crime of character-assassination. By as much as character is dearer to every noble man than life, by so much is character-assassination deeper in criminality than the assassination of the body. He who points at your person the weapon of death faces a punishment of equal degree, and is entitled to whatsoever consideration courage may merit in the accomplishment of an evil deed; but he who points at your reputation the deadly weapon of character-assassination, encounters no such risk, nay, too often he stands loftily up and pharisaically plumes himself upon his superior moral altitude while he strikes the dagger through that which is dearer than life to you. Cowardice, there is none greater, pharisaical villainy, there is none blacker than that which lifts its irresponsible hand against the character of a fellow being. In its milder forms—alas in too many cases its scarcely milder forms—this evil finds a place in the press, the pulpit, the platform, the sewing circle, the club, the unnumbered places of assemblage, nay, it even finds a place in the private circle and at the hearthstone.

In so far as this is a conscious, purposeful crime, the mild slow gentle influences of intellectual and ethical training are relatively impotent agencies of reform. Stronger and more direct remedies are demanded, since the evil, in such cases, springs not from intellectual processes but from a pronounced moral degradation. It is a declared moral disease and drastic remedies applied directly to the abnormal functions rather than

hygienic and preventive measures are needed. The slow moral effects induced by intellectual habit might, in the course of time, undermine the sinister attitude of the mind and lead to a more wholesome condition, but a quicker and more direct remedy is needed. This is a case in which direct assault is the better strategy.

But by far the greater evil, at least the wider evil, springs not from criminal intent but from defects of intellectual action and from faulty attitudes of the mind. Misjudgment of others springs in some large part from a want of rigorous scrutiny of the evidence upon which judgment is predicated. Rumors, reports, suggestions, innuendoes are accepted without sufficient inspection. Ofttimes they bear in their very nature elements of sheer inconsistency. Stories that would not bear for a moment a rigorous inspection of their coherence are accepted without scrutiny and form the basis of sinister conclusions. The habit of close inspection of all statements before acceptance, the practice of withholding judgment from imperfect data, the rule of looking upon all sides before arriving at a conclusion, in short, the fundamental scholarly habit of mind, if given full play, would eradicate the larger percentage of this enormous evil and eliminate with it an incalculable measure of poignant suffering which the best and most sensitive natures are continually forced to endure.

Among the sinister influences now affecting our body politic, one of the most baneful, to my judgment, is the indiscriminate, wholesale, inconsiderate denunciation of our public servants. Moral denunciation has unquestionably a most important function to perform in restraining corruption and unfaithful public service. But when that denunciation is applied without individual discrimination, without a careful and conscientious regard for its justness, it tends to defeat its own object. The honest man is from his very nature more sensitive to reflections upon his integrity than the rogue, and if they are equally lashed by the assumed reformer, or by the pharisaical preacher of civic righteousness, the greater punishment falls upon the just, while the unjust pockets the reward of his villainy, and chuckles over the smartings of his more honest fellow official, while he enjoys the price of corruption. It is indeed important that official malfeasance shall be denounced, but it is equally and more im-

portant that faithful conscientious public service should receive the reward to which it is entitled from every good citizen whether agreeing or disagreeing in political belief or party affiliation. It is of supreme importance that we exalt the integrity of the just and that we protect faithfulness against calumny. To the end that just denunciation shall fall upon the unfaithful and just honor upon the upright, it is the duty of every good citizen to scrutinize with the utmost skepticism every accusation directed against a public servant, testing its inherent character, weighing it in the balances of impartiality, withholding credence unless it be supported by evidence, in short, putting it to the same tests to which the student of science subjects natural phenomena before he accepts its indications or assumes to form a judgment upon it. It is a function of investigative study to introduce into the social and political atmosphere those habits of impartial scrutiny, of conservative judgment and of regard for the exact truth which are calculated to protect the innocent and bring down upon the guilty the full and conclusive evidence of their criminality. The spread of investigative study, increasing as it must necessarily these truth-searching habits of the mind, will slowly but surely develop more just, and therein more effective, personal treatment of public officials.

The extension of the impartial methods of thought and the catholic sympathies which are pre-requisites of creative scholarship, must, in the very nature of the case, diminish that partisanship of spirit and that partiality of inquiry and of presentation which are pronounced evils in our political world. In so far as men become lovers of the exact and the full truth in all its many-sidedness, in so far will they cease to be narrow partisans. Men will still continue to believe that one line of policy is better than another, and will still repose more confidence in one organization of citizens for political purposes than in others, but they will yield less servile devotion to partisan measures and party leaders. Men will cease to see in any one policy or party the summation of all good and in others the summation of all evil; will fail to see in the exponents of one party the perfection of personal wisdom and integrity and in the exponents of the opposite party the aggregation of all folly and corruption, because impartial inquiry will show its falsity. Four years ago there

went up from one political host the cry "turn the rascals out," and there came up from the other political host the answering cry "keep the very hungry and very thirsty from the fountains of government." The change came, and a most rigid investigation of the records of the government failed to show any notable malfeasance in office, and I venture the prediction that if a reversal of administration shall follow the coming election, no prevalent corruption will be found in the conduct of the government. The charge of rascality does not, I think, in the cool judgment of the careful student, lie against any of the major organizations of the American people or their chosen representatives as a class. In so far as men become accustomed to make close discriminations and to arrive at careful judgments will they find that there is a mingling of good and of evil in all organizations and in all policies, and that the task of the real patriot is to evaluate these as they are applied to men, measures and parties, and to be guided by the results rather than by servile party fealty. Measures the most just in general are unjust in particular. Measures the most beneficent on the whole are injurious in the individual instance. No narrow rule, no mere platform, no simple set of measures will be found adequate to the solution of all the complex problems of civic growth and governmental administration. The solution must come through a most careful and conscientious study of each problem in all its multifarious aspects, and the higher the investigative spirit and the lower the partisan spirit, the more hopeful the results.

The propagation of the spirit of untrammelled inquiry is working and is destined still more fruitfully to work a beneficent modification in the phases of religious thought. A genial change is gradually creeping over the theological discussions of our times and bringing with it broader sympathies, a more truth-reverent spirit, a more just recognition of the good and the ill in current doctrines. More important perhaps than all is the recognition that the more sacred the field of thought, the more imperative is the obligation to enter upon it freed from bias, trained to the utmost precision in discrimination, possessed by the highest candor of spirit and equipoise of temper, and inspired by absolute devotion to the truth. If the truth be here more sacred than elsewhere, the more sacred is the duty that unalloyed truth be discovered, and the more assiduously is it to be sought; and

he who here would bind the wings of thought is he who would restrain thought from its highest, its loftiest, its purest, its most sacred flights.

The spirit of creative scholarship has yet another important function to perform in the fullness of its influence, the guidance and restraint of reformatory movements. It is but natural that when the consideration of an evil has become entrenched upon a mind, that it should magnify itself until it gradually mounts up before the view in its amplitude and shuts out the vision of other truths; and so the mind is led, in its warfare against a special evil, to overstep the bounds of just judgment in other relations and transgress the limits of wisdom and prudence. This danger becomes especially imminent when the evils to be reformed reside in others and not in ourselves. Reformatory movements are herein liable to excess injurious to themselves and harmful to other interests that also demand consideration. These excesses do indeed direct attention more pointedly to the evils sought to be removed, but it is to be questioned whether this good compensates for the evil of the excess. Certainly to the scientific judgment any swerving from the truth falls under moral condemnation even though its purpose be reform, though its inspiration be moral enthusiasm, and though its efforts be directed against an acknowledged evil. Scientific thought postulates as a fundamental axiom that supremely laudable results are only to be reached by integrity of intellectual action in every particular, in every stage of progress, and in every expression of enunciation. It assumes that men will be led to the acceptance of the better in thought and in action, more surely and more rapidly, in the end, by a precise, candid presentation of truth, than by exaggeration or undue emphasis. The dangers of reaction from an unwholesome enthusiasm and the bitter after-taste of an untruthful statement are thereby avoided.

Turning for a moment to individual virtues it may be remarked that impartial devotion to truth antagonizes undue self-regard. The habit of impartial scrutiny must often reveal one's own weakness. The judicial attitude of mind forces one to step out from himself and view his own positions and personal relations in the same damaging light as those of others. All opinions stand alike before the true student. The opinions of yester-

day are things of yesterday. Ones old opinions are as all old opinions, entitled to respect in the precise measure of their truthfulness and in no other, save as historic relics. It is indeed a moral attitude. It is indeed superhuman to sit in judgment upon one's own opinions, robed in the same judicial ermine with which one enwraps himself when he adjudicates the opinions of others. From our very nature our affections go forth to our own intellectual children and to treat them as we would treat the offspring of others is in contravention to the law of parental affection. We only avoid this by rising into the higher plane of affection which embraces within its reach all intellectual creations in the impartiality of a universal affection. To this lofty habit we fail to attain, but it is the function of a catholic and candid search for the truth to lead us upward to those lofty realms.

So likewise, in so far as devotedness to truth frees us from our natural partialities, it fosters candor in thought and action. This candor is often an expression of the highest moral courage; a loftier and truer courage than springs from personal bravery, or pride of opinion, or self-conceived heroism. It is the courage of simple conviction. It is not the courage of the intellectual warrior clashing swords with an antagonist over some battled question in which marshaled antagonisms enter to stimulate the individuality, but rather that pacific courage which rests its confidence in the ultimate triumph of its own truthfulness, which puts forth its conclusions, not in battle array, but simply in their logical relations, trusting not to any marshaling against attack, but rather to their inherent strength. It is the refined courage of intellectual peace, not the gross courage of intellectual war. The calmness with which the author of the most wide-reaching of modern hypotheses set forth his array of facts and inferences, and the quiet, courageous and noncombative spirit with which he received the onslaught made upon him from all quarters of the heavens, constitutes one of the sublimest examples of serene personal courage that human history has witnessed. Great as has been the intellectual contribution of Mr. Darwin to the thought of his time, it is perhaps scarcely greater than the moral influence of his supremely candid spirit.

I had hoped to find a remaining moment in which to invite your attention to other ethical effects of investigative study,

and especially to the important consideration that in so far as candid and impartial habits of mind are developed, in so far is there laid the ground-work of hope for the propagation of all doctrines that have in themselves the elements of truth. It is in the interest of every sect and party which really embodies truth and depends upon this embodied truth for its success, that an inquiring and impartial spirit should become prevalent, for it is only from minds controlled by such a spirit that converts to the truth can be rationally expected. But upon this I may not dwell.

The summation of my argument is this: investigative study calls into continuous exercise certain noble activities and attitudes of the mind; to love the truth supremely, to seek the truth assiduously, to scrutinize evidence rigorously, to withhold judgment when evidence is insufficient, to look upon all sides equally, to judge impartially and to make conscientious corrections for personal bias. The continued exercise of these sterling activities during the formative stages of the mind develops corresponding fixed habits of thought and forms a permanent disposition which influences all subsequent action for good. This disposition displaces other dispositions upon which immoral tendencies more easily implant themselves. It thus works at the very source from whence spring moral issues. Its effects are slow and unobtrusive, but radical and pervasive.

THE COAL MEASURES OF CENTRAL IOWA, AND PARTICULARLY IN THE VICINITY OF DES MOINES.

BY CHARLES R. KEYES.

With the exception of a few cursory examinations the stratigraphical geology of Polk county, Iowa, and particularly that of the region in the immediate vicinity of Des Moines has received but little attention. Owen * apppears to have been the first to make any geological observations in the region under consideration; his remarks, however, are very brief, and relate only to a few unimportant exposures on the Des Moines and Racoon rivers. Worthen || in the report on his reconnaissance of the Des Moines valley, makes mention of two expos-

*Geol. rep. Iowa, Wisc. and Minn., 1852, pp. 121, et 129.

Geol. Iowa, I, 1858, p. 170.

ures of micaceous sandstone and the associated shales and clays, at Des Moines; White's † remarks upon this regional geology are also few. The meagerness of both of these accounts is due largely to circumstances entirely beyond the control of those engaged in the geological study of Central Iowa. The cenological features in the vicinity of Des Moines have received considerable more attention, and many important details disclosed.§ Recently there have also appeared some notes on local palæontology.‡

The topography of Polk county is essentially characteristic drift, except in the immediate proximity of the two principal streams, where through the lower part of the middle—and the upper portion of the lower coal measures the Des Moines and Racoon rivers have corraded their channels nearly one hundred feet below the general level of the sedimentary strata of the vicinity. Aside from the surface deposits the rocks exposed in Polk county belong to the age of the coal measures—the middle (of White and St. John) and the lower. No sub-carboniferous strata are naturally exposed within the limits of the county, but, inasmuch as the St. Louis limestone is brought to view in the Des Moines river about thirty miles below the city of Des Moines, itis quite evident that they lie at no great distance beneath the surface. The Chester limestone so well developed in some portions of the contiguous states is not represented inIowa; and the coal measures of the state, as has been shown by White,* rest unconformably upon the St. Louis limestone. The stratigraphy at, and in the immediate vicinity of, the confluence of the Des Moines and Racoon rivers has recently been more clearly indicated than at any previous period, chiefly on account of numerous newly made road and railway cuttings, and borings, though for the most part the records of the latter are, and will be for some time, inaccessible.

The following are a few only of the sections examined:

SECTION I. *Railway Cutting N. E. N. W. 8, 78 N. 24 W.*

		Feet.	Ins.
10.	Soil	1	0
9.	Brownish yellow drift clay	2	0
8.	Clay shale (Carboniferous)	2	0

†Geol. Iowa. II. 261.

§Call, Am. Nat. XVI, p. 369; McGee & Call, Am. Jour., Sci. XXIV, Sept., '82.

‡Am. Geologist, Vol. II, p. 28.

*Geol. Iowa, Vol. I, p. 225, *et seq.*

		Feet.	Ins.
7.	Blue, impure nodular limestone weathering brown	0	8
6.	Drab shaly clay	5	0
5.	Blue limestone similar to No. 7	1	0
4.	Light colored shale	5	0
3.	Bituminous shale	3	0
2.	Impure shaly coal	3	0
1.	Variegated clays	15	0

SECTION II. *Railway Cutting S. W. S. W. 2, 78 N. 24 W.*

		Feet.	Ins.
6.	Soil and drift	1	0
5.	Yellowish micaceous, sandstone, somewhat concretionary in places and often containing much pyrite	25	0
4.	Yellow and drab clays	1	8
3.	Impure shaly coal	2	6
2.	Yellow and drab clays somewhat sandy in places; upper 12 inches containing rootlets of *Stigmaria*	4	6
1.	Impure shaly coal (exposed)	2	0

SECTION III. *Excavation at Tile Works, N. E. N. W. 3, 78 N. 24 W.*

		Feet.	Ins.
11.	Soil	0	6
10.	Yellowish-brown drift clay	4	0
9.	Variegated shales and clays	15	0
8.	Impure shaly coal with layers of bituminous shale	4	0
7.	Impure argillaceous sandstone with rootlets of Stigmaria in upper portion	2	6
6.	Shaly coal	1	0
5.	Dark drab shales and clays	3	0
4.	Dark, nearly black, clayey shales containing crystals of selenite in abundance	7	0
3.	Yellow sand and clay	0	6
2.	Hard black fissile shale	1	6
1.	Hard drab clay, exposed	6	0

SECTION IV. *Road Cutting, on river bank, N. E. N. E. 34, 79 N., 24 W.*

		Feet.	Ins.
7.	Soil	0	6
6.	Sandy, brownish-yellow drift clay	7	0
5.	Loess, containing *Helicina occulta*, *Succinea obliqua*, *S. avara*, etc., typical loess below mingled with drift above	6	0
4.	Straticulate sand, clay, with gravel and boulders up to 1 foot in diameter exposed	14	0
3.	Hidden	11	0
2.	Impure shaly coal	2	0
1.	Irregularly thin bedded sandstone with numerous clay partings exposed	5	0

SECTION V. *Giant Coal Mine, S. W. S. E. 36, 79 N. 24 W.*

		Feet.	Ins.
6.	Drift clay and carboniferous clays and shales	56	0
5.	Coal (No. 1)	4	0

		Feet.	Ins.
4.	Shales and clays	20	6
3.	Coal (No. 2)	4	6
2.	Clays and shales, lower layers highly fossiliferous	35	0
1.	Coal (No. 3)	4 ft. 6 in. to 6	0

SECTION VI. *Altoona Coal Mine, S. W. N. E. 13, 79 N. 23 W.*

		Feet.	Ins.
6.	Drift and carboniferous clays and shales	110	0
5.	Shales	60	0
4.	Sandstone	15	0
3.	Coal	1	6
2.	Shales and clays	15	0
1.	Coal	4	0

SECTION VII. *Boring, near Mitchellville 1, 79 N. 22 W.*

		Feet.	Ins.
14.	Drift and carbonaceous clays	64	
13.	Yellow sandstone	4	
12.	Blue shales	11	
11.	Bituminous shales	1	
10.	Impure limestone	0	6
9.	Impure shaly coal	1	2
8.	Light colored clay shales	8	
7.	Bituminous shales	66	
6.	Blue clayey shales	21	
5.	Sandstone	3	
4.	Gray clay and sand shales	21	
3.	Argillaceous sandstone	16	3
2.	Light colored shales	6	4
1.	Limestone with marly partings	39	6

SECTION VIII. *Boring near Des Moines, 13? 78 N. 24 W.*

		Feet.	Ins.
15.	Drift and carboniferous clays	36	
14.	Sandy, blue, black and gray shales	25	
13.	Sandstone and sand shales	6	
12.	Bituminous clays and shales	27	3
11.	Dark colored sandstone	4	
10.	Gray and blue sand shales	11	
9.	Dark blue shale	13	
8.	Sandstone with shaly partings	13	6
7.	Light colored clayey shale	7	
6.	Limestone	1	2
5.	Gray and blue clayey shales	26	
4.	Bituminous shale	12	
3.	Blue limestone and sandstone	14	
2.	Bituminous shale	5	6
1.	Light colored sandstone	6	

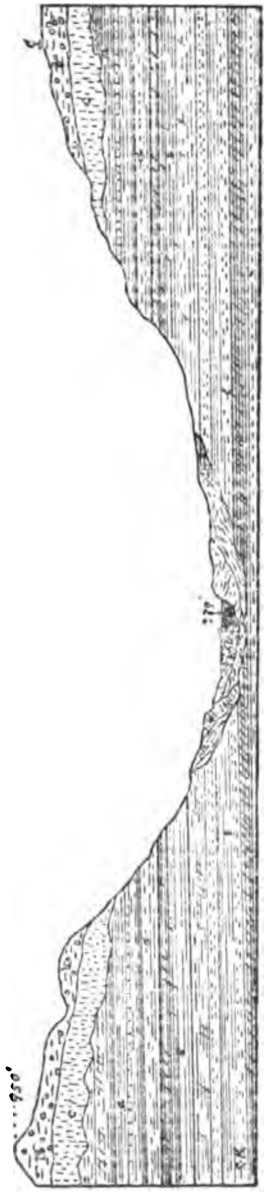
The sedimentary rocks of central Iowa in accordance with all of the palæozoic strata of the state, have a general dip to the

south-westward. The lower coal measures which over a greater part of this region are covered by drift, pass beneath, in the south-western portion of Polk county, the middle coal measures, the most eastern extension of which is approximately at Des Moines. In Iowa the lower coal measures have probably a maximum stratigraphical thickness of over two hundred and fifty feet, but in the county, though this formation is completely represented, from the underlying St. Louis limestone to the superimposing variegated shales of the middle coal measures, this maximum is perhaps nowhere attained. The productive coal measures of the region under consideration are, as shown clearly in the accompanying sections, composed almost entirely of clays and shales, with a few unimportant beds of friable sandstone and, in the proximity of Des Moines, at least three persistent coal seams, besides other irregular and thinner carbonaceous layers. The section at the Giant coal mine is a typical one for the immediate vicinity of Des Moines, though at different places the thickness of the three workable coal beds, and their distance from each other varies somewhat. Coal No. 1 (Section V) although in many places four feet in thickness, is mined but little, chiefly on account of its somewhat inferior quality, the prevalency of clay seams, and the existence only a short distance beneath of two better and more profitably worked beds. No. 2 and particularly No. 3 are the most extensively mined coals, and furnish nearly all of the coal obtained in the county, which in 1884 amounted to 620,000 tons. The thickness of the former is four feet; that of the latter forms four to seven feet. The roof of coal No. 2 is usually much better than that of either Nos. 1 or 3, being made up of two or three feet of shales, overlaid by fifteen to eighteen feet of sandstone. No. 3. is far more valuable economically than either of the other two important seams; and occupies a much greater area. It is overlaid by a soft bituminous clayey shale, often slaty in places, and is highly fossiliferous; * it also contains much iron pyrites in the form of crystals and nodules; and the fossils contained have the original calcareous material replaced more or less completely by pyrite. Upon exposure to the atmosphere the pyrite rapidly decomposes and the shales quickly

* A list of the fossils from these shales will be found in this journal, vol. ii, p. 25.

disintegrate into a fine black clay. For this reason the roof of coal No. 3. is not very substantial, and soon after the coal has been removed, unless properly protected, large masses are continually becoming detached. This gradual destruction of the roof is often attended by still more serious consequences especially just east of the city of Des Moines, on account of the presence above the roof shales of much sand and water. Although here the coal is much thicker than elsewhere in the county it is almost impossible often to obtain it for reasons just stated, and lately several mines within this area, have been flooded and abandoned.

The observations here presented, supplemented by those made in various other portions of the Iowa coal field, appear to be indicative of the infeasibility of correlating the different coal horizons. In the region under consideration the numerous sections point to an attenuation, in all directions from the city, of the Des Moines coal fields. Other portions of the state afford similar phenomena in corroboration of the suggestions already presented, proving conclusively that the individual coal beds of Iowa are not as continuous nor as extensive as has hitherto been supposed. It is not to be inferred, however, that the aggregate amount of coal in the state is actually less than has usually been considered, but rather that the various seams of coal instead of being continuous over wide areas as is popularly regarded, are disposed in a series of broadly lenticular layers; or in separate basins, having a maximum thickness in the direction of the approximate centre, and becoming greatly attenuated toward the borders. The areas occupied by the various coal basins might thus encroach upon one another; and a boring in one locality would thus disclose coal horizons which only a few miles away would be entirely unrepresented. The above diagram illustrates this supposed attenuation of three coal beds at different horizons.



SECTION ACROSS THE DES MOINES RIVER, SSW FROM THE STATE CAPITOL.

Scale: horizontal, 2½ inches=1 mile; vertical, 1 inch=150 feet. Low water in the Des Moines 779 feet above sea. *a, a,* alluvium: *b, b,* drift; *c, c,* loess; *d, d,* middle coal measures; *e, e,* lower coal measures.

SECTION IX. (Partly diagrammatic) showing the deposition of the coal seams in Central Iowa.

Mention has been made incidentally of the existence of clay seams in some portions of coals Nos. 1 and 2. A portion of these are doubtless due, as has been suggested by Newberry,* to currents of water which corraded through the coal beds and associated strata—a fine sediment having been afterwards deposited; but some of these seams present different characters, being filled with "rubbish" (as called by the miners)—pieces of wood, branches and trunks of trees, etc. In cases of this kind the chamber that is being worked is immediately closed with solid masonry to prevent the ingress of water. The wood is similar to that found in the "forest bed" often met with in sinking shafts, and it would thus appear probable that the corraded channels in the carboniferous strata might have been filled during glacial times.

The city of Des Moines is situated just at the eastern border of the middle coal measures, the base of which as characterized by St. John, and as is well shown in different sections, is composed of variegated clays and shales, with one or two intercalated bands of impure, nodular, limestone. These variegated shales have a thickness at Des Moines of thirty

* Geol. Ohio, Vol. II, p. 173.

feet, and are exposed at a number of places in the bluffs of the vicinity. The limestone bands are from eight to twelve inches thick and in places fossiliferous. On Capitol Hill at an exposure on the corner of Court avenue and east Ninth street these calcareous layers are separated by only four feet of clay; while a quarter of a mile south-east of this locality, on the Wabash railway, the lower band is overlaid by a marly seam, an inch and one-half in thickness, which affords *Productus muricatus* N. & P. and a number of other species in greatest profusion.

These bands have yielded the following fossils:

Rhombopora lepidodendroides Meek.
Cyathophyllum torquium Owen.
Lophophyllum proliferum McC.
Eupachycrinus cragii. M & W.
Synocladia biserialis Swallow.
Chonetes verneuiliana N & P.
——— mesoloba N & P.
Productus semireticulatus Martin.
——— muricatus N & P.
——— cora d'Orb.
Athyris subtilita Hall.
Retzia mormoni Marcou.
Spirifera radiata Sow.
——— camerata Morton.
Spiriferina kentuckensis Shumard.
Streptorhynchus crenistrius Phillips.

The present separation of the lower and middle coal measures does not appear, at least in the vicinity of Des Moines, to be sustained by either the stratigraphical or lithological characters; nor is the palæontological evidence in harmony with such a division. It is indeed to be doubted whether in Iowa the coal measures are really separable into more tha two well marked sections. The evidence in substantiation for such a division need not be considered here, though it may be stated that it is at an horizon considerably higher than the variegated shales just alluded to, that the fauna of the strata designated as middle coal measures begins to assume an upper coal measures facies; and that it is even higher before the lithological characters approach those of the upper division.

Apropos to the casual reference to the cenological features of this portion of the state, mention may be made to the recent discovery in the drift at Des Moines of a mass of rather soft ferruginous sandstone, charged with fossils of unmistakable Cretaceous type, the greater part of which are in a good state of preservation. When first discovered the mass was perhaps two feet in diameter and contained upwards of a dozen species of fossils. A few of the best preserved specimens were taken at the time, and the place revisited a few days later for the purpose of securing the whole piece, but unfortunately workmen had broken and removed it. The species obtained were: *Otodus appendiculatus* Ag., *Lamna Texana* Roemer, *Fasciolaria cul-*

bertsoni M. & H. *Lunatia concinna* M. & H. Announcements have already been made of the occurrence in the drift of Iowa beyond the limits of known Mesozoic strata *in situ* of Cretaceous fossils and fossiliferous sandstone. Dr. White has reported an ammonite from Waterloo, Iowa, a fragment of bacculite from Iowa City* and six specifically determinable forms from Hardin county† and he has shown that the facies of the fossils in question has a close affinity with the fauna of the Fox Hills group, or the uppermost portion of the marine Cretaceous of the continental interior. The recently discovered Des Moines specimens afford additional evidence in support of this supposition. The good preservation of the molluscan remains though so fragile, together with the fact of the comparative softness of the ferruginous sandstone, suggests as in the other instances mentioned, that the fragments of cretaceous strata are not far removed from the locality of original deposition. The satisfactory determination of the eastern extension of the Cretaceous in Iowa is attended with much difficulty, chiefly on account of the great depth of the drift, covering north-western portion of the state, but doubtless outliers will be discovered considerably to the eastward of the present ascribed limits.

PRELIMINARY DESCRIPTION OF A NEW OR LITTLE KNOWN SAURIAN FROM THE BENTON OF KANSAS.

By F. W. Cragin.

The saurian here described was found in Osborne county, Kansas, in limestone of the lower part of the Benton, a few feet below the base of the dark septaria-bearing shale.

It exhibits all of the essential features of the order *Sauropterygia*, being, in fine, a short-necked plesiosauroid, with long and narrow paddles consisting proximally of three bones abutting against three distinct facets of the humerus or femur, in the latter character resembling the genus, *Beptanodon*.

If not identical with the *Piratosaurus* of Leidy, which is known by but a single tooth not now available for comparison, it represents a new genus and species, for which I propose

* Geol. Iowa Vol. I, p. 98. Also Proc. Am. Ass. Ad. Sci. Vol. XXI. pp. 187-192.
† Am. Geol. Vol. I., p. 228.

Trinacromerum as the generic and *bentonianum* as the specific name, and which may be characterized as follows:

Generic Characters.—Muzzle long and narrow, with a median carina above and below. Teeth conical, curved, with plicate enamel, those of either jaw forming with the corresponding of the other a regularly spaced series of shearing pairs. Neck short. Vertebræ amphicœlous, with shallow articular concavities; the neural arches anchylosed with the centra without trace of suture; neural canal spacious; centra of the cervical vertebræ quadrate, transverse, and depressed; those of the dorsal vertebræ subcircular, cylinders generated by a line that presents a slight convexity toward the axis, the cylinders broader than long. Sacrum composed of two cylindrical vertebræ with massive diapophyses whose stout short ribs meet distally for the support of the ileum. Swimming paddles long and narrow, those of the anterior and posterior pairs not very unequal in size, the supposed posterior being slightly the larger; both furnished with numerous phalanges (many more than in plesiosauroids generally); humerus and femur stout, proximally expanded into a subspherical and obliquely directed head with pitted surface for the articular cartilage; greater tuberosities and trochanters prominent, separated from the head by a constriction which, passing round the bone a little below the articular surface, forms a short but distinct neck; a large deltoid ridge and impression; proximal portion of the shaft of both humerus and femur subcylindrical, showing, as do the head and neck of the same, a slight compression in a plane that makes a large angle with that of the middle and distal portions which become rapidly compressed to the flat and very broad distal extremity; this extremity presenting three interangulated concave facets, with the anterior two of which articulate the radius and ulna (or tibia and fibula) and with the third and posterior of which articulates a pentagonal carpal-like bone, followed by a second which is smaller and tetragonal. Radius, ulna, tibia, and fibula transverse and subquadrilateral. Tarsals and carpals six, polygonal, arranged in two transverse rows; intermedium hexagonal, transverse, related to the paddle as in *Plesiosaurus*.

Specific Characters.—Premaxillary portion of the muzzle considerably higher than the mandibulary, both portions boat-shaped, median keel of either narrow but pronounced, that of

the latter becoming obsolete at one and a half to two inches back of the tip of the mandible. Teeth moderately stout, conical (mostly ovate in cross-section), gently curved, and separated by about their average length or about twice their average major diameter at emergence from socket; enamel raised into longitudinal folds which vary in width and abruptness, being often undeveloped on much of the outer aspect of the tooth. Either jaw presenting more or less decided marginal impressions for the reception of the teeth of the other. Spinous processes and pedicles of the neural arch compressed and of medium antero-posterior extent; the former of quite moderate hight. Hypopophyses represented on the cervical vertebræ by a ridge made prominent by the presence of a large vascular foramen on either side of it; on the dorsals by a ridge which, though constant, is much less pronounced. (On a supposed lumbar vertebra the hypopophysis is again more prominent, but on those of sacrum and first sacro-caudal it is nearly obsolete.) Contiguous borders of radius and ulna (and of tibia and fibula) each with an emargination. Distal of the supernumerary carpal-like bones about a third as large as the proximal; latter with inner border resting against ulnare (or fibulare) and with free border angulated. Proximal phalanges more or less spool-shaped, distal ones much flattened, or becoming (in the first, second, and fifth digits) rudimentary; phalanges of the anterior three digits of a shorter and broader type than those of the anterior two. Phalanges of the first digit 9 (?10) in number; those of the second digit not less than 15 (not more than 17); of third digit at least 17, (not more than 19); of fourth at least 16 (not more than 19); of fifth probably 15 (not less than 14 and probably not more than 17); last two phalanges of first digit rudimentary, the number of rudimentary phalanges in the second and fifth digits probably somewhat variable.

Measurements.

	Feet.	Inches.
Hight of muzzle 2.75 inches from tip........................	..	2.63
Breadth at same point......................................	..	1.63
Length of exposed portion of shortest tooth preserved........	..	.71
" " " longest " "	..	1.12
Average length of five anterior teeth.......................	..	1.00
" " centra of several larger dorsal vertebræ..	..	2.81
" " same	..	8 78
" " "	..	8.61

	Feet.	Inches.
Anterior sacral vertebra: length of centrum................	..	2.89
" " " breadth "	..	3.69
" " " hight "	..	3.56
" " " length of spinous process*........	..	2.75
" " " " rib.....................	..	3.94
" " " horizon. diam. of rib at neck (about)	..	1.00
" " " vertical " " diapophysis at articulation with rib	..	2.37
" " " horizontal diameter of diapophysis at articulation with rib.........	..	1.75
Length of one of the swimming-paddles, partially restored and including femur (? humerus), about.................	4	5.50
Breadth of same across base of intermedium................	..	3.20
" " " tenth phalanx from tip of third digit.	..	3.13
Length of femur (? humerus), about......................	1	7.00
Greater and lesser diameters of shaft of a femur (? humerus) at point where latter is most nearly cylindrical, respectively	..	3.50 and 3.00
Thickness of femur (? humerus) at distal extremity...........	..	2.68
Breadth of same at distal extremity........................	..	9.50
Greater and lesser diameters of head of same, respectively...	..	5.27 and 4.52
Circumference of neck of same...........................	1	1.75
Greatest length of tibia (? radius)........................	..	3.44
" breadth of same..................................	..	4.63
" length of fibula (? ulna)	..	2.80
" breadth of same..................................	..	3.00

A fuller paper on this form, with illustrations, will appear in the Bulletin of the Washburn College Laboratory of Natural History, Topeka, Kansas.

KEOKUK GROUP AT CRAWFORDSVILLE, INDIANA.

By Chas. S. Beachler.

The rocks of the Keokuk group, consisting of soft sandstones, limestones and clay shales, occupy the entire central area of Montgomery county, Indiana, extending in a broad belt from north to south across it. They are everywhere, except along the streams and hillsides, hidden and covered with glacial deposits from one to one hundred and fifty feet in depth. In drilling for natural gas the drill penetrated two hundred and eighty feet of shales and limestones of this formation before reaching the shales of the Devonian. The following section was observed at the crinoid beds:

	Feet.
Sandstone, containing fossils	30
Blue shale, crinoid beds	5
Limestone, encrinal	2
Blue shale, containing fossils	25
	62

The Keokuk series is wholly of marine origin, this being determined by the remains of plants and animals, the plants being fucoids and the animals being corals, crinoids and marine shells. The overlying arenaceous rock in places, marks distinctly the wave action of the sea. In the argillaceous and calcareous rock the lamination is regular and generally thin, the intervals of quiet being marked by the massive beds.

The horizontal position of the strata was assumed in obedience to the law of gravity; and after elevation parallel with the Cincinnati anticlinal, the variation was slight, dipping toward the west.

The "geode bed" which forms the upper series of the group in Iowa and western Illinois, is wanting at this locality; the fifty feet of regular bedded calcareous rock exposed at Keokuk, Iowa and Nauvoo, Illinois is represented at this locality by fifty feet of arenaceous and argillaceous rocks; the lowest series of the group, consisting of cherty limestone and forming the transition beds between the Keokuk and Burlington groups is also wanting at this locality.

It will be seen from the above facts that the Keokuk limestone on the west border of the central coal field, becomes arenaceous on the east.

The Keokuk group, like all of the Sub-carboniferous formations, thins out and disappears east of this locality.

The characteristic fossils of this formation are the *Agaricocrinus americanus*, *Forbesiocrinus meeki* with several other species of crinoidea peculiar to this locality; and these are associated with *Platyceras equilatera*, *P. sub-rectum*, *Archimedes owenana*, *Spirifer cuspidatus* and *S. sub-orbicularis*, which clearly establish the true horizon of these shales and sandstones as stratigraphical equivalents of the Keokuk limestone of Illinois and Iowa.*

It might be well to add here the species *Productus magnus*

*Geol. Rep. Ill., vol. 1, p. 101.

which is exclusively a characteristic fossil of the Keokuk group.*

Up to this date no vertebrate remains have been determined.

In preparing this article and following catalogue of fossils I must acknowledge special indebtedness to professors Leo Lesquereux of Columbus, O., E. T. Cox and J. S. Newberry of New York city, James Hall of Albany, N. Y., A. H. Worthen of Springfield, Ill., James D. Dana of New Haven, Conn., and to J. M. Coulter of this city.

Also to Charles Wachsmuth and Frank Springer for the use of their work "The revision of the Palæocrenoidea" published in the proceedings of the Philadelphia Academy of Natural Sciences.

List of fossils of the Keokuk group at Crawfordsville, Indiana.

PORIFERATA.

Cleodictya (sp. inedt.) Hall.

CŒLENTERATA.

[Several specimens of the genus *Zaphrentis* have been found at this locality, but no definite species have yet been determined except in one case; Ind. Geol. Rep. 1875, gives *Zaphrentis dalli* Edwards and Haime, also the species *Aulopora gigas* Rominger, *Amplexus fragilis* White and St. John, *Syringopora* (sp.?)]

ECHINODERMATA.

CRINOIDEÆ.

Species marked with an * are referred to said genus for the first time by Charles Wachsmuth and Frank Springer in their work on the revision of the Palæocrinoidea from which this list of crinoids has been compiled.

1881. *Agaricocrinus springeri* White. Geol. Rep. Ind., 1881.

*1868. *Barycrinus herculeus* Meek and Worthen. (*B. hoveyi* var. *herculeus*) Proc. Acad. Nat. Sci., Phila., p. 341. Geol. Rep., Ill., vol. v, p. 485, pl. 18, fig. 2.

1861. *Barycrinus hoveyi* Hall. (*Cyathocrinus hoveyi*) Desc. New Pal. Crin. p. 5, Bost. Jour. Nat. Hist., p. 293. Meek and Worthen, 1873, *B. hoveyi* Geol. Rep. Ill., vol. v, p. 486, pl. 18, fig. 1.

* 1859. *Batocrinus indianænsis* Lyon and Casseday. (*Actinocrinus indianænsis*) Amer. Jour. Sci. and Arts, vol. xxix, p. 75. Meek and Worthen, 1873. *Actinocrinus indianænsis* Geol. Rep. Ill., vol. v, p. 341.

* 1880. *Batocrinus wachsmuthi* White. (*Actinocrinus wachsmuthi* not *A. wachsmuthi* 1862—*Actinocricrinus scitulus*.) Author's Edit. from 12th Annual Rep. U. S. Geol. Surv. by Hayden, p. 162, pl. 40, figs. 1 a. b. Geol. Rep. Ind., 1879-80, p. 142, pl. 7, fig. 6.

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*Prof. A. H. Worthen to author in letter, dated March 28, '88.

1869. *Calceocrinus bradleyi* Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 78, also 1873 Geol. Rep. Ill., vol. v, p. 502, pl. 14, fig. 9.

1868. *Catillocrinus bradleyi* Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 342; also 1868, Geol. Rep. Ill., vol. v, p. 504, pl. 14, figs. 10 a. b.

1865. *Cyathocrinus arboreus* Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 160; also Geol. Rep. Ill., vol. iii, p. 520.

1879. (?) *Cyathocrinus harrisi* S. A. Miller. Jour. Cin. Soc. Nat. Hist., vol. ii, pl. 15, fig. 2.

1869. *Cyathocrinus inspiratus* (?) Lyon, Trans. Amer. Philos. Soc., vol. xiii, p. 457, pl. 27, fig. k.

1859. *Cyathocrinus mltuibrachiatus* Lyon and Casseday. Amer. Jour. Sci. vol. xxviii.

1870. *Cyathocrinus poterium* Meek and Worthen. Proc. Acad. Nat. Sci., Phila, p. 24. Geol. Rep. Ill., vol. v, p. 489, pl. 12, fig. 4.

1860. *Dichocrinus ficus* Casseday and Lyon. Proc. Amer. Acad. Arts and Sci., vol. v, p. 24; Meek and Worthen, 1873; Geol. Rep. Ill., vol. v, p. 500, pl. 14, fig. 1.

1860. *Dichocrinus polydactylus* Casseday and Lyon. Proc. Amer. Acad. Arts and Sci., vol. v, p. 20.
Syn. *D. expansus* Meek and Worthen (not De Kon and Leh., 1853.) Proc. Acad. Nat. Sci., Phila., p. 344; also Geol. Rep. Ill., vol. v, p. 500, pl. 14, fig. 1.

1858. *Forbesiocrinus Wortheni* Hall. Geol. Rep. Iowa, vol. i, pt. 2, p. 632, pl. 17, fig. 5.

* 1859. *Ollacrinus tuberosus* Lyon and Casseday. (*Goniasteroidocrinus tuberosus* and type of that genus.) Amer. Jour. Sci. and Arts., vol. xxviii, (ser. 2) p. 233; Wachsmuth and Springer, Proc. Acad. Nat. Sci., Phila., p. 263.

1859. *Onychocrinus exsculptus* Lyon and Casseday. (Typical species.) Amer. Jour. Sci., vol. xxix, p. 78.
Syn. *Onychocrinus* (*Forbesiocrinus*) *norwoodi* Meek and Worthen. Geol. Rep. Ill., vol. ii, p. 245, pl. 18, fig. 3.

* 1859. *Onychocrinus ramulosus* Lyon and Casseday. (*Forbesiocrinus ramulosus* L. and C. not Hall.) Amer. Jour. Sci., vol. xxviii, p. 235.

1865. *Platycrinus hemisphericus* Meek and Worthen. (*Pleurocrinus.*) Proc. Acad. Nat. Sci., Phila, p. 162; also Geol. Rep. Ill., vol. iii. p. 466, pl. 16, fig. 9, and vol. v, p. 16, fig. 6 a. b. c.

1870. *Poteriocrinus* (*pachylocrinus*) *concinnus* Meek and Worthen. (*Pot.* [*Zeacrinus*] *concinnus.*) Proc. Acad. Nat. Sci., Phila., p. 26; Geol. Rep. Ill., vol. v, p. 490, pl. 14, fig. 3.

1869. *Poteriocrinus* (*Scaphiocrinus*) *coreyi* Meek and Worthen (not *Pot. coreyi* Worthen. Geol. Rep. Ill., vol. vi, p. 514.=*Pot. Scytalocrinus grandis*, W. and Sp.) Proc. Acad. Nat. Sci., Phila., p. 148; Geol. Rep. Ill., vol. v, pl. 15, fig. 1.

* 1870. *Poteriocrinus* (*Decadocrinus*) *depressus* Meek and Worthen. (*Scaphiocrinus depressus.*) Proc. Acad. Nat. Sci., Phila., p. 27; Geol. Rep. Ill., vol. v, pl. 14, fig. 8.

1878. *Poteriocrinus* (*Scaphiocrinus*) *gibsoni* White. Proc. Acad. Nat. Sci., Phila, p. 31.

*1879. *Poteriocrinus* (*Scytalocrinus*) *grandis* Wachmsuth and Springer. (Described *Poteriocrinus coreyi* Worthen, 1875.) Geol. Rep. Ill., vol. vi, p. 516, pl. 29, fig. 2, 3, (not *Pot.* [*Scaphiocrinus*] *coreyi* M. and W. 1869.)

1878. *Poteriocrinus* (*Scaphiocrinus*) *gurleyi* White. Proc. Acad. Nat. Sci., Phila., p. 32.

1865. *Poteriocrinus* (*Scytalocrinus*) *indianænsis* Meek and Worthen. Proc. Acad. Nat. Sci., Phila, p. 155; Geol. Rep. Ill. vol. iii, p. 515, pl. 20, fig. 4.

1861. *Poteriocrinus nodolrachiatus* Hall. Desc. New Pal. Crin., p. 8; Bost. Jour. Nat. Hist., p. 614.

1861. *Poteriocrinus* (*Scytalocrinus*) *robustus* Hall. Desc. New Pal. Crin., p. 7; Bost. Jour. Nat. Hist., p. 315.

*1879. *Poteriocrinus* (*Pachylocrinus*) *subæqualis* Wachsmuth and Springer. (Type of the group described by Hall, 1861, as *Scaphiocrinus æqualis*, not *Pot. Scaphiocrinus æqualis*. Hall, 1859.) Desc. New Pal. Crin., p. 8. Bost. Jour. Nat. Hist., p. 316. Meek and Worthen, 1873, Geol. Rep. Ill., vol. v, pl. 15, fig. 6.

1861. *Poteriocrinus* (*Scaphiocrinus*) *unicus* Hall. Desc. New Pal. Crin., p. 8; Bost. Jour. Nat. Hist., p. 313; Geol. Rep. Ill., vol. v, pl. 15, fig. 5.

*1858. *Taxocrinus multibrachiatus* Lyon and Casseday. (*Forbes iocrinus multibrachiatus*.) Amer. Jour. Sci, vol. xxiii. Labelled in most American collections, *Forbesiocrinus meeki* Hall.

*1861. *Vasocrinus lyoni* Hall. (*Cyathocrinus lyoni* type of the genus.) Desc. New Pal. Crin., p. 5; Bost. Jour. Nat. Hist., p. 298; 1868, Meek and Worthen (*Barycrinus lyoni*); Proc. Amer. Acad. Nat. Sci., Phila., p. 340.

Syn. *Cyathocrinus hexadactylus* Lyon and Casseday, 1859. Amer. Jour. Sci., p. 74.

BLASTOIDEÆ.

1858. *Pentremites wortheni* Hall. Geol. Surv. Iowa, p. 606; also Geol. Rep. Ill., vol. v, p. 606, pl. 15, fig. 1.

ECHINOIDEÆ.

PERISCHOECHINIDÆ.

1868. *Lepidesthes coreyi* Meek and Worthen. Geol. Rep. Ill., vol. iii, p. 525.

ASTEROIDEÆ.

1868. *Onychaster flexilis* Meek and Worthen. Geol. Rep. Ill., vol. iii, p. 526; also vol. v, p. 510, pl. 16, fig. 3.

1869. *Protaster gregarius* Meek and Worthen. Proc. Acad. Nat. Sci., Phila., p. 169; Geol. Rep. Ill., vol. v, p. 509, pl. 16, fig. 5.

EDRIOASTERIDÆ.

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MOLLUSCA.

MOLLUSCOIDEA.

BRYOZOA.

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(?) Productus cora d'Orbigny. Voyage dans l'Amerique dele Meridionale. Ind. Geol. Rep., 1883, p. 125, pl. 26, fig. 1, 2, 3.
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LAMELLIBRANCHIATA.

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1865. *Lithophaga? lingualis* Meek and Worthen. Proc. Acad. Nat. Sci., Phil., p. 245; Ill. Geol. Rep., p. 586, pl. 19, fig. 1, 2.

GASTEROPODA.

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PTEROPODA.

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1859-60. *Conularia crawfordsvillensis* R. Owen. Ind. Geol. Rep., 1859-60, p. 364, fig. 9.

ARTICULATA.

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NOTES ON A GEOLOGICAL SECTION AT TODD'S FORK, OHIO.

By Aug. F. Foerste.

Todd's fork is a small tributary of the Little Miami river. North of Wilmington, Ohio, on the road to Xenia, a bridge crosses the stream. At the water's edge, a little streak of blue clay can be seen. This is said to be the top of a layer of blue

clay eight feet thick, exposed to better advantage farther down the stream. Beyond this, its entire course lies over the rapidly alternating shales and limestones of the Cincinnati group. A few hundred feet up stream, on the left bank, is an interesting exposure of the overlying rocks. At the stream's edge arises a series of layers of a bedded, sandy rock. Its total thickness is five feet; a foot from the upper part of the same, a few somewhat more shaly courses contain a number of annelid teeth. The rock is greenish grey in color, turning almost drab on weathering. It is referred to the Medina. Above lies a series of limestones, eighteen feet thick. The lower part is whitish in color, hard, with tendencies towards bedding. This passes into a pinkish tinted rock above, without bedding, containing rarely a few of the more common favositoid corals. This feature is preserved until within six feet of the summit, when the rock rapidly assumes a reddish tinge, this becoming more decided above, and terminating in a reddish brown iron ore, which now and then has an oolitic structure. The deposit would be valuable for smelting, did it exist in larger quantities. Above the pinkish rocks, fossils become very abundant, especially so in the iron deposit. This series forms the Clinton group of Ohio. Ascending the stream as far as the next bridge, an exposure will be found on the right bank. The lower eight feet are composed of a whitish crystalline stone, with quite regular bedding, and unfossiliferous. It is the Dayton limestone. Above this are one or two feet of a rock varying towards dolomyte, with a dirty blue color, also unfossiliferous, introducing the Niagara shales. The next rock in the series is seen to better advantage at Moody's quarry, one mile east of Wilmington. It is a dolomitic, loosely textured rock, very fossiliferous, belonging to the Guelp series. This completes the list of rocks traversed by Todd's fork.

The Cincinnati rocks seen in the creek bed belong to the upper, or Lebanon beds. The stratification is very regular and approximately horizontal. The blue clay layer marks a period of disturbance intervening between the deposition of the Upper and Lower Silurian periods. It varies greatly in thickness; at Fair Haven, near the Indiana line, it is scarcely more than a foot thick; at Soldiers' Home, near Dayton, it is perhaps three or four feet thick. At the Soldiers' Home exposure a number

of *Orthis occidentalis*, and *O. biforata* are found imbedded in the clay, but of an unhealthy appearance when compared with similar forms from the strata immediately below. As a rule the blue clay layer is unfossiliferous, excepting at its very base. The blue clay seems to have been the result of erosive action and to have been deposited under the influence of litoral currents. At any rate at the close of the deposition of the layer of blue clay, the bottom of the ocean was no longer flat here, but subject to many undulations, caused by depressions in the blue clay layer.

The so-called Medina is found also at Fair Haven, here however reduced to two feet in thickness. A large annelid shell formerly seen at this locality suggested that the sandy rock was synchronous neither with the Cincinnati nor Clinton deposits, being distinct from the species of either group, but it was not otherwise determined. In addition to this, the annelid teeth of Todd's fork are the only fossils. Too little is known of annelid teeth at present to be of value as means of identifying the horizon. It will be seen therefore that our correlation was based entirely upon lithological grounds. A similar layer in Indiana has been identified with the Clinton group, a nomenclature which we are not inclined to follow, seeing that the true Clinton rocks are also found there in many places.

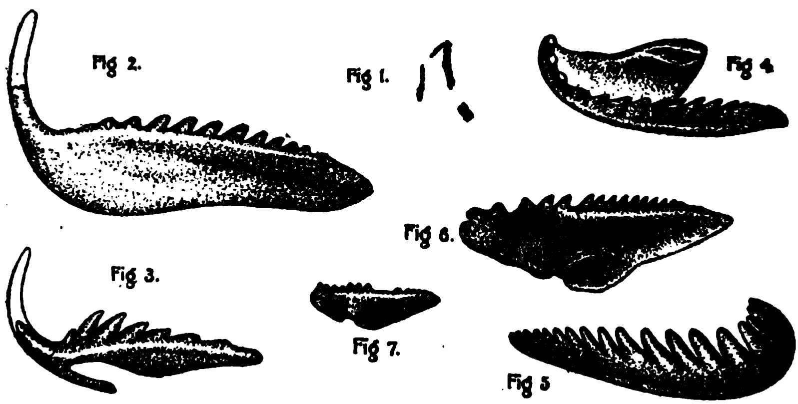
The Clinton group of the state usually reposes directly upon the blue clay layer. The Medina is only occasionally found. Owing to the irregular surface of the blue clay, the Clinton rocks, though of fairly uniform thickness, often appear as irregular, often isolated lenses, with thinned edges, these lenses forming the lower parts of the series, filling the hollows of the blue clay, the rest having been worn away by the deunding action of glacial and other phenomena. Owing to the irregularity of the blue clay, and the consequent irregularity of all superposed strata, thicknesses of the Clinton, not measured, but calculated by altitude of base in one locality and summit at some neighboring exposure, have probably given rise to some of the high estimates made by Ohio geologists. Fifteen to twenty feet will express the hight of all exposures actually measured by us, but these belong to the summit of the Cincinnati anticlinal. It is not unusual to find all except the upper parts of the Clinton group comparatively barren. This is true

also of Huffman's quarry, south of Dayton. Here the quarrymen report the Clinton limestone to be thirteen feet thick although this may be slightly underestimated. Only a foot or so at the top is well supplied with fossils. Above this are about nine inches of a bluish stone containing a number of fossils distinct from anything in the Clinton below, many of them of small size. This is the Beavertown marl, at Huffman's quarry, sharply divided from the Clinton below, paleontologically and lithologically. In the upper fossiliferous (ferruginous) beds at Todd's fork however, they are blended together, the marl does not exist at all, and several of the forms peculiar to the marl are here found commingled with abundant Clinton types. *Orthoceras inceptum* and *Raphistoma affinis* are the most common of the marl fossils found here. Todd's fork thus offers a connecting bridge for these two divisions of Upper Silurian strata. In its lithological features it is also equivalent to the ferruginous Clinton of Kentucky. Some fossils are also common to both, the most interesting of which is *Ptilodictya expansa*. The form with almost parallel sides is extremely rare, except at Todd's fork, where it is the only form seen. This other form is found abundant at the Soldiers' Home, and other quarries near Dayton. In it, the sides are more or less curved, widening auteriorly and it cannot be distinguished from specimens of *Pt. lanceolata* collected in Gotland, an island near Sweden. The Kentucky Clinton is probably of slightly later age than the Clinton of Ohio.

The Dayton limestone is a local variation of the base of the Niagara shales as recognized in Ohio, and consists of regularly bedded limestones of whitish color, passing above and at the edges gradually into the dolomitic limestones of the Niagara shales. Both limestones and shales are unfossiliferous at Todd's fork, as is usually the case. At Huffman's quarry, however, near Dayton, various species of corals have at times been found, belonging to the genera *Favosites*, *Syringopora* and *Strombodes; Strombodes pygmæus* suggesting an age equivalent with the Niagara limestones of Michigan and Kentucky. The Waldron beds of Indiana correspond to the upper part of the Niagara shales, and contain a few forms introductory to the Guelph above. The West Union and Springfield rocks of Ohio geologists often become merged with the Niagara shales and the

Guelph, so as to lose their distinctive character. In Indiana their place is taken by the Waldron series of rocks. At Todd's fork nothing seems to intervene between the Niagara shales and the Guelph rocks, and although no single exposure is continuous enough to give the total hight of the shales themselves, it is very likely not more than 30 feet.

The Guelph exposures near Wilmington are lithologically and paleontologically equivalent to the Cedarville beds of Ohio and the Niagara dolomyte of Chicago and Racine. Fossils are abundant, especially cephalopods. *Pterinea brisa*, in its typical form, is also present. The genus *Illænus* has also several representatives.



Annelid Teeth.

The annelid teeth of the Medina at Todd's fork are, as usual, small, black, shining bodies, often too minute to be readily discerned by the unassisted eye, freqently standing out in relief, entirely uninjured, upon the weathered slabs of the sandy shales. Associated with them are little sheets of a similar black substance, sometimes forming narrow bands, 75 mm. in width, and 11 mm. long. Such bodies are generally associated by collectors with graptolites, but most probably they represent the chitinous skin of the annelid, of which the teeth are the more tangible evidence. The teeth of living annelids are known to be exceedingly variable in form, according to their position in the mouth. Dr. George J. Hinde, the first serious student of these forms in a fossil state, has proposed a classification into genera which combine features similar to those of genera now living, the generic name of the fossil forms usually recalling the name of some similar living genus. In consequence, very different forms of teeth are associated generically. We doubt, however, whether this classification has either great theoretical or practical value. Combinations of teeth seen in living genera can scarcely with safety be presumed to have existed in types so early in

the geological scales as Silurian rocks. Nor do we believe the practical value to be very great, because there are many forms of teeth which could safely be placed in two or three genera, as far as analogies with living genera are concerned. Nevertheless, we believe that the only basis for a more practical classification lies in the collection of a greater number of fossil forms than now known, and hence we adopt a confessedly poor classification for the time being.

OENITES DERIPIENS, *sp. n.*

Fig. 2.

Resembling *O. cuneatus Hinde*, but larger, 2.6 mm. in length. Serrated along the upper edge, the teeth directed backwards, about 10 in number, the first one or two indistinct, preceded by a vacant space, anterior to which arises a large fang-like tooth, whose tip was broken off in our specimen. This tooth does not lie in the same plane with the main body of the fossil, but bends toward the left, giving rise to a concave curvature of the body of the tooth along its anterior third. A ridge just beneath the row of teeth becomes very marked posteriorly.

ARABELLITES PROCURSUS, *sp. n.*

Fig. 3.

This species resembles *A. ascialis Hinde* in the existence of a very small tooth introducing a series of larger teeth, but the succeeding teeth are much smaller than in our species. A comparison with *A. aciculatas James* of a lower horizon, is more pertinent, but, judging from the published figure of that form, the smaller tooth is larger than in our form, and the succeeding teeth are irregular in size. It is also considerably larger than our form, which measures scarcely 1.8 mm. in length. The curvature of the large anterior tooth in our drawing is in part conjectural. The first in the row of teeth is quite minute, and is situated at the base of a very large tooth, which is the largest tooth in the row. The next teeth are successively smaller, all of them being directed backwards. There are seven teeth in the row, the last seeming scarcely more than undulations on the upper edge of the tooth. A very marked ridge running along the body of the fossil, from the large anterior fang-like tooth, beneath the row of teeth, to the posterior extremity, and an indentation along the base of the tooth, causing a part of the same to extend backwards as a narrow projection, in line with the lower edge of the same, are the only remaining features of note.

LUMBRICONEREITES AUSTINI, *sp. n.*

Fig. 4.

This species is quite common and is very distinct from any species hitherto described. Teeth from both the left and right side of the mouth have been found. The one here figured and described is a left tooth. The length is 2.3 mm. The body is flat, incurved along the left edge and also posteriorly, the posterior border extending to the sixth tooth in the row of teeth. A longitudinal groove along the postero-lateral border of the body is its only prominent feature. Along the left edge is a high, sharp ridge, quite straight along the serrations, but curving decidedly at its anterior

border, so as to meet the right edge of the body. Along this curved portion are three, rather stout, and fairly rounded, but not markedly prominent teeth. The remaining teeth form a straight row, are much flattened laterally, are directed backward, and decrease gradually in size posteriorly. Owing to the position of the teeth, the anterior teeth of the row, which are in reality about as prominent as those of the middle portion, appear as mere undulations in the drawing. A series of undulations extend along the left side of the fossil, the grooves of which run from the teeth to the not very distinct marginal rim. Named in honor of Dr. S. M. Austin.

EUNICITES FALCATUS, *sp. n.*

Fig. 5.

This species is likewise very distinct from any species hitherto described. It consists essentially of a sickle-shaped fossil, moderately curved behind, decidedly incurved anteriorly, and lined with a series of teeth, all of which are directed backward. The teeth are all flattened laterally; the first three, owing to the curvature of the shell, form a set quite by themselves, being almost at right angles to the main set of teeth along the side. A tooth at the beginning of the sickle-shaped curvature has an intermediate position, being at the same time the largest tooth, from which point the teeth decrease regularly in size,— rapidly along the anterior curve, gradually toward the posterior extremity. A narrow margin extends along the base of the fossil. The fossil is 2 mm. long.

EUNICITES CONFINIS, *sp. n.*

Fig. 6.

This fossil, in many respects, is so much like *Lumbriconereites triangularis Hinde*, that it might almost have been considered as a tooth from the mouth of the same animal, and immediately contiguous to the same, had there been evidence of the unserrated part folding back upon the tooth along its posterior extremity. The depression at the base of our form is also unnoted in Hinde's species, nor have we the elevated ridge extending from the middle teeth to the opposite basal angle. Otherwise there is considerable similarity. The first two teeth appear broken, and not in line with the rest, the body of the tooth being concavely curved anteriorly. Then follow four teeth at moderate distances apart, of which the first two are probably injured. The remainder of the teeth are closely set, and smaller, rapidly decreasing in size posteriorly. The posterior part of the fossil is convexly bent so that there may once have been a recurved portion attached, but there was no evidence of its existence visible. A ridge runs along the posterior half just beneath the teeth; a broad longitudinal depression occupies the remainder of the surface. The tooth is 2. 3 mm. long.

EUNICITES PAULULUS, *sp. n.*

Fig. 7.

This fossil is very small, .6 mm. in length. It is broadly triangular in outline as in the last species described. Anterior to the basal angle is a semicircular notch which may have been accidental. The first tooth of the series is fairly prominent, the next three are quite small, the next three

are the largest of the series, beyond these lies a vacant space which shows no trace of the former existence of teeth if there were any here, finally there are four teeth decreasing in size posteriorly, an indistinct fifth tooth, beyond which there are no serrations. At the anterior extremity below the first tooth is a scar perhaps locating another tooth; this part of the fossil is elevated. A ridge beneath the posterior teeth extends anteriorly as far as the sixth tooth from the front. The thin basal rim is slightly curved up forming thus a narrow basal border.

EDITORIAL COMMENT.

The Fifty-Eighth Meeting of the British Association.

The association met this year on September 5th, for the third time, in the old and historic city of Bath. Most of the English cities have now in the long life of the Association received more than one visit; and not unnaturally a part of the by-speaking consists of a review of the time that has elapsed since the previous meeting. In the present case this period covers 24 years (1864–1888.) The city of Bath is one of those that has been the seat of human residence since very early times. Race after race has left its mark on the city and the surrounding country. The luxurious Romans during their long stay in Britain discovered the healing and pleasurable Hot Springs and established themselves in the region which, perhaps, reminded them of their own Baiæ on the shores of the Mediterranean. Issuing from the ground at a temperature of about 117° in large quantity, these springs supplied them, in the cool, moist atmosphere of Britain, with baths whose warmth was as grateful as the coolness of their companion waters in the hot Italian climate. Aquæ Sulis or Solis, as the city was then called, was a resort of the Roman and Romano-British population of the island for many years, and the relics of their buildings are often disentombed. An excellent example may now be seen, recently excavated, which has brought to light an extensive establishment, containing a large swimming bath (70 by 30 feet), and several other smaller baths, for the use of ladies and for therapeutic purposes. The water in the former now stands four feet deep, and the tank is entirely paved with sheet lead, in large plates half an inch thick. The Roman supply pipe still remains, and

an adjoining well, from which 10 tons of sheet lead were lately taken, was used as a reservoir for the warm water.

The city of Bath was defended by a line of vast fortified camps against the Saxon invaders. Some of these camps probably date from times much more ancient even than that period, but were re-occupied by the Romano-Britains during the Saxon invasion. The great battle of Deorham (577, A. D.), at the camp of the same name, was the decisive conflict. The Saxons were masters of the field, and the cities of Bath, Cirencester and Gloucester fell into their hands and were sacked and destroyed. From this camp the members of the Association, who visited the spot on Saturday, could look over the whole flat country and understand the value of these natural fortresses, when strengthened by man. After that date the city was deserted, or nearly so, for many years. The mud and silt accumulated in the Roman bath to a depth of 10 feet, burying the tank, the columns and the portecoes, so that they were completely lost to view. In one corner was found a wild duck's egg, showing the desolation of the once crowded city. Other buildings ultimately rose on the ruins, and the bath was almost forgotten. Accident revealed it a few years ago, and it now forms, or will form when fully excavated, one of the most interesting historic monuments of this historic city.

The Geological Section met on September 6th and proceeded at once to business by hearing an address from its president, Prof. W. B. Dawkins, of Manchester, on the relative value of the evidence drawn from different forms of life in the correlation of the cenozoic strata. This author, as is well known, has long insisted on the special importance of the mammalia for this purpose during the tertiary age, and naturally, therefore, reverted to this topic, pointing out how their rapid evolution supplies a more delicate chronometer than that afforded by the slow development of the invertebrata. It gives us, as it were, a larger dial plate on which the slow advance of the hand can be more readily detected, and, consequently, the intervals of time more exactly measured, than in any other way. On this principle Prof. Dawkins proceeded to divide the Tertiary and Post-tertiary strata (objecting, it should be added, to the use of the latter term) into stages marked by the presence or absence of certain forms of mammalia, and in this way he out-

lined a geological chronology of the period on zoological data. The professor concluded by pointing out the continuity of the series, and objecting to the exclusion of the historic period from the domain of geology, adding a short summary of the relation of man to the ice age, and alluding to the difficulty, at present, of expressing geological time in chronological terms, because of our ignorance of the rate of action of the various causes. "We may," he said, "draw cheques on the bank of Force, as well as on the bank of Time."

Several papers were read on the secondary, especially the Jurassic rocks of England. This subject has, of late, obtained special attention in consequence of the hope which has been indulged that water might be found in some of the lower beds sufficient to aid in supplying the metropolis. Thus far the reward, though substantial, has not come up to the expectative, but there is reasonable ground for anticipating useful, if not abundant, supplies. Borings also, some of them yielding cores 12 inches in diameter, have been made to prove the existence of palæozoic rock at no very great depth below London. The hope is still entertained that workable seams of coal may in this way be found in the south-east of England, as such seams were found by the French government by similar borings in the north of that country.

Dr. Persifor Frazer followed with a paper, in which he advocated the Archæan nature of the rocks found in the nucleal ranges of the Antilles. During a visit this year to the south-eastern part of the island of Cuba, the speaker had made some examinations of the rocks which form the nucleus of the spurs of the Sierra Maestra, and there is strong reason to believe of the axial range of the entire island and of Jamaica, Santo Domingo, Puerto Rico, and the Windward islands as well. From the field observations there made, and an examination of the specimens under the microscope, it seems highly probable that these rocks, instead of being igneous extrusions of the Tertiary period and later, are in reality of much earlier date, and may not be entirely volcanic. Several considerations support this view. Microscopic analysis shows immense alteration to have taken place, and, consequently, a very long period to have elapsed. The complexity of the congeries of rocks forbids the hypothesis of their having been derived from one mass. Where this congeries, therefore, is unconformably adjacent to the Tertiary, there can be no rea-

sonable doubt that the crystalline rocks are the elder. The characters of the several associated rocks are those which one finds united in very many Archæan regions throughout the world. The products of alteration of these rocks are similar to those which one finds in the districts just alluded to. The chemical peculiarities of the iron ores found in contact with these rocks are similar to those which one finds in the ores of the Archæan regions, both in the low percentage of phosphorus and in the pyrite and (more sparingly) chalcopyrite disseminated through the ore, and in other respects. If this nucleal mass had been forced up from the earth's interior in a state of igneous fusion, there would not be now (as there are) abundant cases of stratification and structure, implying an original sedimentation. If this mass had resulted from volcanic outflow, there must have been contact phenomena, and changes induced on the surfaces of the rocks with which it was brought in contact. No such contact alteration has been observed between these rocks and either of the three groups which meet them. The direction of the range, considered as a whole, lends support to the hypothesis that it is a fork of the Andes which, diverging from the main axis in Guatemala, traverses the peninsula of Yucatan, and in a symmetrical curve sweeps through the highlands of Cuba and Jamaica, Hayti, Puerto Rico, the Windward islands, and the north-east coast of Venezuela. This run of high land once enclosed the Caribbean as another Mediterranean sea. The shapes of the hills of this range, produced by weathering, are not those usually visible in regions of volcanic, but rather of metamorphic, rocks. The rocks which furnished the basis for the above conclusions are all, or nearly all, alteration products. In some cases they appear to be the result of a second, third, or even greater number of metamorphoses, some of their constituents seeming to pass through cycles of change, ending in the mineral with which the alteration began after a number of intermediate stages. The rocks are diorytes, with epidote, porphyritic dolerytes, which resemble and have been taken for syenites, garnet rock, actinolite, felsyte and orthofelsyte porphyry, like that of the South mountain of southeastern Pennsylvania, of St. David's Head in Wales, and elsewhere. To these are added pyrite and iron ores. Copper and manganese ores are not rare, but their relations to the rocks under consideration have not been made out.

On Friday a lively discussion followed the reading of Dr. Crosskey's report on the erratic blocks, and his paper on a high level boulder-clay in the Midland district. No new points, however, were brought out in the paper, in which the author advocated the distribution of these boulders by the action of floating ice, rather than by that of glaciers, a view in opposition to that entertained by several speakers in the discussion that followed. All who took part, together with the author of the paper and the president of the section, spoke in feeling terms of the late Prof. Carvill Lewis, whose early and unexpected death has deprived American geology of a promising worker in the glacial field.

The work on Saturday commenced with a comparison by Prof. Marsh of the principal forms of Dinosaurians in Europe and America. Prof. Marsh's views being already in print, it is not necessary to repeat them here. In replying, Prof. Seeley, while differing from the speaker in some points, took occasion to express high appreciation of Prof. Marsh and his labors in American vertebrate palæontology.

Prof. Osborn then made some remarks on the development of the mammalian molar teeth to and from the tubercular type. He pointed out a line along which the conical tooth of the reptile may have passed to the form with three tubercles. This was during the Oolitic age. Then came the Cretaceous, with its single mammal, breaking the chain of evidence; and when that had passed away, the mammalian molar was found in the lower Eocene. Prof. Seeley added a little further evidence of the same kind, and Prof. Gaudry gave a short address (in English) on the comparative size of some of the fossil mammalia. Two short notes followed, read by the secretary in the absence of their authors, on the amount of carbonic acid in the atmosphere in past ages, and on the occurrence of a gneissic pebble in the Halifax coal.

Two geological excursions were made on Saturday afternoon to the great oolite quarries at Box, where the workings are carried on underground at a distance of about two miles from the opening and to a long section of the Carboniferous limestone, passing down into the Old Red sandstone without unconformability. Many members took advantage of the opportunity of visiting the similar but much grander display of the same rocks

at the Avon gorge, below the city of Bristol, where the river has cut a channel 300 feet deep, exposing several thousand feet of strata, the section extending from the Old Red sandstone near its base to the coal measures, the upper part being repeated by a fault having a throw of 800 feet, and passing across the gorge nearly at right angles.

Monday's session was, for the most part, occupied with a series of papers by Drs. Anderson, Johnston-Lavis and Claypole on various points more or less directly bearing on volcanic phenomena. Much interesting material was brought forward, and a lively discussion maintained. The first-named author showed by the lime-light a set of photographs of the volcanoes of the two Sicilies. These were very good and elicited general admiration. Dr. Johnston-Lavis read a letter received by him from a friend, describing vividly an eruption of *Volcano* in August last, when, after a sudden suspension of activity, red hot stones were thrown out to the distance of three-fourths of a mile, some of which measured 15 yards in length. One of less size fell through the roof of his house. Another, four feet in diameter, dropped close by him as he left his home, and, broken by the fall, burned his children's feet. Hundreds of others were scattered over the slopes or fell back into the crater of the volcano. The same observer also noted the occurrence of metallic iron in a Vesuvian lava, and of leucite in a lava from Etna.

In the evening a lecture was delivered by Prof. T. G. Bonney on "The Foundation Stones of the Earth's Crust." The subject was the structures of the so-called primitive rocks, the gneisses, etc., of which the oldest known beds are composed. It was, of course, impossible, in such an address, to enter into minute points of detail, and the speaker very wisely confined himself to laying before his audience, with the aid of a lantern, the basal facts on which the new science of petrology rests. He showed clearly the difference between a gneiss, with its confused and uncrystalline appearance, and a true granite, showing the rectilinear edges of its crystalline elements. He then passed on to the effects of pressure on these foundation stones, taking the ground that pressure alone does not produce structural change, but that such structural changes are due to shearing movements in the rock, which behaves like an imperfect liquid. In this way mica plates and scales are developed from feldspar, and layers

or films of such plates produce the stratified, or, rather, the foliated appearance of many mica-schists. He passed on to refer to the recently discovered fact that hornblende schist may be, and has been, formed in the same way from dolerite. He brought forward clear testimony in favor of the opinion that a certain genetic development might be traced in these minerals by which their age may be approximately determined. It is needless to dwell at any length on the expression by so eminent a petrologist of his settled belief that these crystalline rocks belong, as masses, to a distinct and definite early stage in the history of the earth, and that the conditions under which they were formed were different from any now existing, though it is possible they may be occasionally reproduced on a small scale.

The greater part of the session on Tuesday was devoted to some papers on coral reefs and their mode of formation. After an introductory paper by Dr. Hickson, stating with great impartiality the case of both sides in the controversy now prevailing, several other speakers added remarks bearing more or less directly on the subject. As the whole of the discussion, and nearly all the special points brought forward, have been long before the public, it is unnecessary here to reproduce them. It will suffice to say that the heresy promulgated by Mr. Murray in opposition to the theory of Darwin has evidently made great progress among geologists, and that the charge brought by the Duke of Argyll of a "Conspiracy of Silence" to crush the new doctrine, if it ever was true, is true no longer.

A soiree, given by the Bath and Bristol Microscopical Society, took place on Tuesday evening, and the concluding meeting was held on the afternoon of Wednesday. New Castle-on-Tyne was announced as the gathering place for 1889, and Leeds was chosen for 1890. The usual votes of thanks, and the dinner of the Red Lions, closed the meeting of 1888, which, though not large, was pleasant and successful.

There is room for a few remarks on such gatherings as those of the various associations for the advancement of science now existing in many different countries and constantly increasing in number. Even during the meeting at Bath the president read a telegram from Sydney, announcing the first assembly of the Australian Association, with 800 members. The original intention was to stimulate enquiry and promote intercourse

between scientific men and the general public. These objects have been largely promoted, and the cause of science has gained many recruits. In regard to the British Association, it would be difficult to overestimate the results that it has accomplished by judicious grants of money in furtherance of definite lines of research. For example, the grant just made of £100 for aiding the excavation of the Roman bath above mentioned was not only a graceful acknowledgment of the hospitality of that city, but a contribution to a very useful end. For 16 years the Association voted annually the same amount for the exploration of Kent's cavern, which has yielded the most definite evidence thus far obtained in England in favor of the antiquity of man. This method is not yet within the reach of all similar bodies, but should be kept in view as a desirable method of indirect work.

Another extremely valuable branch of the Association's labors is the annual reports of numerous committees specially appointed to investigate various problems requiring much time, labor and patience, but for which no remuneration can be given. Such is the "Boulder" Committee, which has been in existence for many years, and the "Earth-tremors" Committee, of recent creation. Their reports are not read, but handed in with a few remarks by the chairman to the appropriate section. All this belongs to what may be called the "unseen work" of this association, and is really more important than most of the "seen" work done in the sectional meetings. This latter is necessarily of a much more popular and discursive nature, and not altogether above criticism. The faults do not lie altogether with the managers, but are in great part inseparable from the incongruous and miscellaneous nature of the gatherings. It may be worth while to point out a few of these. A notice of some defects that strike the by-stander may furnish hints to all those engaged in similar societies. For example, the plan of holding only a single session from 11 till 3 o'clock has the disadvantage of compelling almost every one to slip away in order to get a lunch, which might be avoided by adjourning at 1 o'clock for an hour, and continuing the session till four. This plan would also afford a pleasant interval for conversation to those who desire it. One other point deserves mention — the bad, indistinct reading of many of those who present papers. It is the duty of a man who claims the attention of an audience to take care that what he says shall be

heard by those to whom it is addressed. This cannot be the case when the paper is held low and the head bent over it, so that the voice is scarcely audible a few feet from the platform. Moreover, in many cases the reading is so rapid, that intelligent hearing is impossible. These faults detract from the interest, and destroy the attention of the listeners.

Further, it is worthy of consideration, if it would not be better, except in a few special cases, to read "by title only" all papers whose authors are absent. A substitute cannot do the paper justice. He often stumbles over the handwriting; he constantly reads too fast; and fair discussion is almost impossible. It is, moreover, just to those who are present to prefer them to the absent.

One other slight matter regarding the conduct of the sectional meeting is worth a moment's notice. It is the practice of some of the chairmen to call on one person after another to address the meeting. No doubt, they deem these the fittest to add elements of interest. Perhaps this judgment may be right; but in most cases it kills discussion, and reduces the so-called argument to the expression of separate individual opinions. The vivacity that springs from quick and prompt remark, question and answer is lost, and attention often flags. Many of the gentlemen called on speak to the point, but in almost all cases some of them merely rise in compliance with the call of the chair, and add nothing of value or interest to the so-called discussion. The chairman, of course, has the right to use his judgment in requesting any well-known man of science to briefly address the audience, but the field should be thrown open to all before the discussion is closed.

Outside of the section there are the various excursions—a very pleasant and valuable feature of the meetings, affording opportunities for conversation and intercourse not otherwise attainable. In the British Association the members taking part pay their own expenses. In the American Association the excursions are usually free. It is a difficult question to decide which plan is preferable in the interest of the Societies. The chief difficulty in both is to resist the tendency to extend the excursions at the cost of the Section, so to reduce the working-time in favor of the pleasure-time. It must be borne in mind that the latter is not to be underrated. It gives opportunity

for intercourse between the visitors and so furthers one of the objects of the meeting. It enables them also to become acquainted with places and objects of interest in a new district without the expense of a special journey. In short the excursion forms an integral part of the business of the meeting, and should by no means be neglected or too much curtailed.

It seems however, to be the general opinion among the constant visitors and the managers of the business of the Association that Saturday afternoon and the Thursday following the meeting afford sufficient accommodation. This opinion is, I think, generally approved, so that practically little trouble is encountered in arranging the necessary details.

In regard to the evening meetings there is greater difference of opinion. It is scarcely in harmony to attend in full dress a lecture on a scientific subject which is practically open to every one. It moreover has a tendency to increase the expense of attending the meetings and to keep away some who would otherwise be present. The same objection may be urged though possibly with less force, in regard to the evening reception. It is doubtful how far the purposes of the Association are advanced by encouraging the use of evening dress to such an extent as to render conspicuous those who do not adopt it. Of course all such accessories add to expense, trouble and fatigue, and are more likely to keep away men and women whose presence would be eminently desirable. Moreover, it naturally tends to set those who reside near the place of meeting at a great advantage and it is at least a matter of questionable taste when the entertainers eclipse the entertained.

But as this is a very moot point we will not enlarge but merely throw it out for consideration. It is a subject which deserves attention not merely at the meetings of the B. A. A. S. but at those of the A. A. A. S. also.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Formal Recognition of the Transfer of the Lick Observatory to the Board of Regents of the University (of California), Sacramento, 1888. 8vo, 24 pp. The geological interest of this publication is found in the responsive address of professor Dr. Joseph LeConte, on behalf of the University, covering pages 14–24. It is an eloquent parallel between the

ranges of thought presented by astronomy and geology, and might be appropriately and profitably reproduced in the pages of the GEOLOGIST, but we are restricted to a brief statement. Of the fundamental conditions of finite existence, space and time, astronomy deals with one and geology with the other. The existences of astronomy extend into infinite space; those of geology into infinite time. Astronomy measures her spaces by earth-radii; geology her times by earth-cycles. As the astronomer beyond the limits of visible worlds, speculates on the existences which dwell in the abysses of space beyond, so the geologist when fossils and rocks fail, speculates on the events of abysses of time anterior and posterior. It is the privilege of astronomy to demonstrate the unity of God thoroughout all space, as it is of geology throughout all time. The sublimity of the dawn of the notion of infinite space full of objects, marks the rise of astronomy; that of the dawn of the notion of infinite time full of events, marks the use of geology. In their relations to mental culture the two sciences are complimentary. Geology has proceeded by long inductive processes to principles from which she is but beginning to reason deductively; astronomy has been content to work out deductively the logical consequences of the law of gravitation, but in its latest phase she is busily gathering up materials for higher generalizations and a new line of deductions. The brief address is rich in suggestions. It carries our thoughts back to Dr. Le-Conte's memoirs many years since on the "time-worlds" and "space-world" of geology and astronomy.

The Beginnings of American Science. The Third Century. An address delivered at the eighth anniversary meeting of the Biological Society of Washington. By G. BROWN GOODE, President of the Society, Washington, 1888, 8vo. pp. 9-94. (From the Proceedings.) A former address traced the progress of scientific activity in America from the time of the first settlement by the English, in 1585 to the end of the Revolution. The present one takes up the consideration of the third century—from 1782 to the present time. It embodies the results of extensive and faithful research, bringing contributions and hints from many an unexpected source. The two addresses form a convenient embodiment of scientific history, for which devotees of science in America owe professor Goode many thanks.

The Coals of Colorado. By Prof. J. S. NEWBERRY, 17 pp. (From the "School of Mines Quarterly," July, 1888.) The coal-bearing rocks of Colorado belong mostly to the Laramie group, the upper division of the Cretaceous system. The principal beds both east and west of the Rocky mountains lie at about the same geological level as those of Castle Valley and Pleasant Valley in Utah, and those of Rock Creek and Evanston on the line of the Union Pacific R. R. The coal of Carbon Station is more recent, lying 1,500 or 2,000 feet higher in the series than that of Trinidad. So also are the coals, of the lignite basin of the upper Missouri. The latter is Tertiary, while that at the falls of the Missouri, like some of the coal basins north of the Canadian line, is of Kootainie or Lower Cretaceous age, and of fresh-water origin. These coals are older than the Dakota sandstone. Dr. Newberry finds the Puget sound coal to be of Laramie age.

All the important coal-beds of Colorado lie in one or the other of two great belts which cross the state from north to south. The most easterly lies along the foot-hills of the mountains; and in this are located the mines of Erie, Franceville, Canon City, Walzenburg, Cucharas, Trinidad, the Raton mountains, &c. These coals however are inferior to those of the western district. The latter district develops good workable coal on the San Juan and its tributaries, but the most valuable deposits occur north of the Gunnison. In the North Fork and at Irwin begins a coal field which reaches north to and beyond the Union Pacific railroad, and west to the Wasatch. In some places 40 to 50 feet of workable coal may be seen in a single section. The quality will compare with any known in the world. It varies from hard and bright anthracite to semi-bituminous, bituminous and open burning coals, all equal to eastern varieties.

Incidentally Dr. Newberry is led to remark that "the true Laramie group is distinct from the so-called Laramie of the upper Missouri, named by Hayden the Fort Union group, and which, in my [his] judgment, should be considered the basal member of the Tertiary." A memoir on the Fort Union flora will soon appear. Prof. L. F. Ward's "Synopsis of the Flora of the Laramie Group" really contains few of the Lower or true Laramie plants, and is chiefly descriptive of the Upper Laramie or Fort Union flora.

Petroleum and Natural Gas in New York state. By CHARLES A. ASHBURNER, M. S., C. E. 8vo, pp. 54, with a colored map, sections of wells, and a map of the Allegheny oil and gas district. A paper read before the "American Institute of Mining Engineers," Duluth meeting, July, 1887; revised to June, 1888. This important memoir contains interesting communications from Prof. Charles S. Prosser, of Cornell University, who has carefully preserved numerous well records of Ithaca, Clyde, Wolcott, Syracuse (State well), and supplied instructive sections (partly from surveys of Prof. H. S. Williams). Mr. Prosser finds the thicknesses of formations in central and western New York generally underestimated.

Glaciation: Its Relation to the Lackawanna-Wyoming Region. By JOHN C. BRANNER, Ph. D., State Geologist of Arkansas. 8vo, pp. 18. (From the "Proceedings and Collections of the Lackawanna Institute," vol. i.) This is a condensed discussion of the facts connected with the drift, and of the theories propounded to explain them. It contains three handsome artotype illustrations and two wood-cuts. It is a presentation well adapted to stimulate inquiry among the young, and especially in the Lackawanna-Wyoming region.

The Jordan — Arabah and the Dead Sea. By ISRAEL C. RUSSELL, of the U. S. Geol. Survey. pp. 16. (Extracted from the "Geological Magazine," Aug. and Sept., 1883.) This is a connected and systematic digest of all which has been published on the natural features of the Dead Sea basin. Mr. Russel's object in this research was to institute comparisons with the "Great basin" in America. He finds many corresponding features.

Microscopical Physiography of the Rock-making Minerals. An aid to the microscopical study of rocks. By H. ROSENBUSCH. Translated and abridged for use in schools and colleges by JOSEPH P. IDDINGS, U. S. Geological Survey. Illustrated by 121 wood-cuts and 26 plates of photomicro-

graphs. 8vo, cloth. Price $5.00. Published and for sale by John Wiley & Sons, 15 Astor Place, N. Y. This much needed translation is announced to be ready on or about Oct. 15, 1888.

Anti-Evolution: Girardeau vs. Woodrow. By JAMES G. MARTIN. This pamphlet is an outcome of the celebrated Woodrow case of the Theological Seminary of Columbia, S. C. It is a review of an article by Rev. John L. Girardeau, D.D., LL.D., in the "Presbyterian Quarterly" for July, 1888. Dr. Martin is a prominent pastor in Memphis, Tenn. This criticism, like the article reviewed, and like the whole treatment which the Woodrow controversy has received from the church, is grounded on purely ecclesiastical considerations. It is a defense of the orthodoxy of evolution, and a demonstration of the scriptural untenability of the pretenses which have been set up in opposition. While such modes of reasoning may be useful within the bounds of ecclesiastical bodies, they do not touch the only vital question, "Is evolution a method of nature?" It is an inquiry within the domain of science, and scientific evidence must furnish the answer. When the answer has been rendered, as it has, all ecclesiastical and philological hair-splittings are irrelevant and puerile. The truth in evolution must quadrate with all that is true; and we may safely test the truth of traditional beliefs by their accordance with the divine truth taught in Nature.

Congres Geologique International, Compte rendu de la 3me Session. Berlin, 1885. This report of the Berlin session was issued but a few days previous to the London session, and hence was not available in any preparations to be made for the London session. It is a noble octavo of cxli and 546 pages, beautifully printed on finest paper, and a worthy successor of the luxurious Bologna volumes. The first part is a "History of the Congress," comprising, after sundry preliminaries, a list of the members of the Congress, 456 in number, a list of delegates to the Berlin session, and the constitutions of the successive bureaux. The second part consists of the labors of the Congress in seven successive settings. The third part consists of scientific communications by Gaudry, Mojsisovics, Newberry, Szabo, Baron de Zigno, Mayer-Ezmar, Reusch, Noetling, Dupont, Naumann, Huyssen, Ochsanius, Posepny, Blanford, Inostranzeff, Dollfus and Powell. The fourth part consists of documents pertaining to the formal business of the Congress, including reports of the committee on uniformity of nomenclature, report of secretary Dewalque, and reports of the national committees of Germany, Belgium, Spain, France, Hungary, Portugal, Roumania and Switzerland, together with various reports of sub-committees on particular formations.

It will be remembered that a report in English of the proceedings of the Berlin Congress was published by the American committee, under the editorship of Dr. Frazer, secretary of the committee; and that the latter has published in the pages of the GEOLOGIST, an abstract of proceedings of the Paris, Bologna and Berlin sessions embracing an account of the origin of the Congress.

The next session is appointed to be held in Philadelphia in 1891. The vernacular of nine-tenths of the delegates will be English, and if French is retained as the official language, the spectacle will be very extraordinary.

On the Fauna of the Lower Coal Measures of Central Iowa, and Descriptions of two new Fossils from the Devonian of Iowa. By CHARLES R. KEYES. From. the "Proc. Acad. Nat. Sci.," Phil., July 31, 1888. Mr. Keyes enumerates 55 species, of which three are described as new. These are *Chætetes lævis*, *Pleurotomaria modesta* and *P. humilis*, illustrated by figures. The faunal features of the assemblage are thus summed up: (1.) In those groups having an optimum habitat marine, there was not only a fewness of species, but also an extreme paucity of individuals. (2.) Brachiopods though well represented in both genera and species, were in fact not as proportionately abundant as might be expected when it is remembered that this type of life had now nearly reached its greatest expansion and culmination, and (3) the fauna was predominantly molluscan—nearly two-thirds of the entire number of species.

The two new Devonian species are *Conocardium altum* and *Cyrtoceras opimum*—also illustrated.

Glacier erosion in Norway and at high latitudes. BY PROF. J. W. SPENCER, PH. D., F. G. S. (American Naturalist, March, 1888. Read before the Am. Asso. for Advancement of Science, 1887.)

Any original observation upon glaciers can hardly fail to be valuable. Speculation so prevails, and seems so inefficient in solving the vexing problems of Quaternary geology, that our main hope is in learning more of the resources of nature by the further investigation of glaciers and other ice agents now existing.

We have in this paper that which has been appreciated even by Norway geologists. Prof. Gustaf Lindstrom, of the University of Sweden, says: "We have not for a long time had such an important contribution to our knowledge of glacial geology. There are really new facts put forth, of which we were ignorant in spite of all that has been written on glaciers in Norway and other lands."

He found glaciers arching over from rock to rock when the underlying surface is uneven. He found that boulders when in contact with the rock below, as a rule become stationary, and allow the ice to flow around them, producing long grooves in the lower surface of the glacier. Surpassing similar observations by Profs. Sexe and Niles, he found this true even upon surfaces sloping quite abruptly down the glacial current. He found that the scoring of rock surfaces was a less frequent result of glaciation than has been supposed. In the bed of a glacier (Fondalen) which contained little sand and a few stones, the rock surface simply appeared weathered with scarcely a trace of scratching or polishing. He found no real case of glacier pushing up a moraine in good orthodox style, though there was a semblance of it in a few instances.

He is fully satisfied that land-ice, never attaining a velocity as he believes over three feet a day, can never push along boulders when they rest squarely on the subjacent rock, much less tear away blocks from their beds, and therefore above the sea glaciers have no eroding power. He claims that great velocity in glaciers occurs only where their base is below the sea level, where flotation may largely explain it, and in such cases rocks may be held firmly as powerful instruments of erosion.

Having shown the inefficiency of land ice he attributes the wonderful examples of planation, scoring and grooving to sea-ice, floe-bergs, and glaciers accelerated by flotation, and presents a full array of all published observations that seem to favor that conclusion. This forms another valuable feature of his paper.

The paper shows an anti-glacial bias of some strength. While this may stimulate to closer observation in that direction, it has apparently hindered in the opposite, and so prevented really correct conclusions. We find no reference to the observations and conclusions of Prof. A. Geikie and his associates, who visited some of the same localities and on the same errand in 1865. They came to quite contrary results. It would have been well if he could have at least attempted a harmonizing of ideas.

His inference that land-ice never sculptures its rocky bed with its embedded boulder seems weakly supported. For, it rests largely on the assumption that its velocity is always insignificant, at least not surpassing that of the Norway glaciers observed, which by his own showing are small and decrepit. Besides, how can the great velocity observed in the seaward end of glaciers exist without a closely corresponding rate above the sea level? And even, if we allow the limitation of velocity assumed, the case is not proved. May not the boulders in the cases observed have *melted* their way through the ice? For the conducting power of rock is about twice that of ice, and would not the relations in this respect be very different, near the edge of the ice and the warm earth beyond, and in the remote depths of a great ice sheet?

In conclusion we feel grateful to the professor for the forcible way in which he presents the claims of floating ice upon the attention of geologists. Formerly too much was ascribed to its action. There came a reaction which we have little doubt has carried the pendulum of opinion too far in the opposite direction. Glacial theories have become dominant, and we might almost say tyrannical. Excavations, scorings and formations of all sorts and magnitudes have been ascribed to this one versatile and all-powerful agent. It seems quite clear that the efficiency of floating ice in similar directions has been largely overlooked. Here seems to be, therefore, a nearly virgin field of investigation. Who will as patiently and thoroughly study this agency as Forbes and others have the glaciers? Who will tell us what is going on to-day in waters where this agency is at work?

CORRESPONDENCE.

Mitchell county, Texas. The Texas and Pacific Railroad, passing east and west through the centre of Mitchell county, crosses the Colorado river at Colorado City. The general course of the Colorado river through the county is south-east, revealing the "Red beds" throughout its course. These beds give character to the soil of the country and to the color of the water, that of the Colorado river being a deep brick red. The "Red beds" were carefully examined for fossils in many places, with but poor success.

Their upper strata near Colorado City include only a few fragments of an undetermined shell four or five inches long, presenting a close affinity to an *Inoceramus*. In the same bed a fragment of a fish spine was also obtained.

The exposed strata in the bluffs at Colorado City include—

1. Eight feet of calcareous conglomerate.
2. Forty feet of gray sandstone.
3. Fifty feet of red beds of sandstone and shale.
4. Twenty-five feet of thickly bedded brown sandstone to the edge of water in Colorado river.

This section will serve to show the prevailing character of the rocks along the Colorado river in Mitchell county. Fifteen miles north the lower brown sandstone contains silicified wood of some coniferous tree. On Wolf creek, and near Colorado City, the fossil wood was found, in a small quantity, carbonized and forming a pure lignite. The presence of this lignite in isolated sticks has caused some prospecting for coal, which, of course, resulted in a failure. The beds of brown sandstone, in many places, grade into a conglomerate, which is sometimes loosely cemented, but at other times is very firm and strong.

Owing to the frequent occurrence of the crumbling conglomerate, the country is in many places covered with numerous water-worn pebbles, leached out from those beds.

Lone Wolf Mountain, in the north-east part of the county, is a hill which rises above the adjacent gently sloping plain about 100 feet, and forms a very prominent landmark that can be seen 25 miles distant. Its top exposes 16 feet of a hard firmly cemented pudding-stone, including various colored quartz pebbles, the rock chiefly cemented by iron oxide, and so well cemented that, when broken, it forms a smooth fracture through the pebble, which breaks with no greater difficulty than the cementing material. This rests upon two feet of ferruginous quartzite, and below it for over 80 feet, extending to the lower plain, we find occasional outcrops of a dirty drab sandstone. Near the mouth of Champion creek, on Colorado river, we find on the hill-top fragments of a drab-colored flaggy limestone, with some blue chert, containing a few obscure remains of Cretaceous fossils. Next below it is 40 feet of conglomerate, with some sandy beds; then 50 feet of red beds—chiefly deep red sandstone,— with some shale beds, some of them beautifully ripple-marked. Flakes of gypsum are occasionally intercalated.

On the higher lands are found, at many places, fragments of limestone like that found at this place—all going to show it to be the highest rock in the county.

The connection of these beds with the overlying Cretaceous was obtained on Silver creek in Nolan county, 12 miles from the Colorado river, as follows:

Cretaceous.
1. Eleven feet ash-drab limestone, containing *Ammonites peruvianus*.
2. Fifteen feet drab shelly limestone, abounding in *Exogyra texana*.
3. Seven feet of limestone with a few fossils.
4. Four feet of brown shelly limestone, abounding in fossils, including *Gryphæa pitcheri*, (small var.), *Ostrea anomiæformis*, *Globiconcha*, etc.

5. Fourteen feet of red-brown and drab thick-bedded sandstone, containing pebbles.
6. Sixty-two feet of coarse and pebbly sandstone, yellowish and whitish, the lower beds ripple-marked.
7. Twenty-seven feet of red, sandy shales.
8. Four feet of yellowish and drab-streaked clay.

No. 6 contains round sandstone concretions, in size and appearance like cannon balls.

The limestone stratum here may with certainty be referred to the lower Cretaceous—Gulf Cretaceous of Hill.

On the hill west of Colorado City, and about 140 feet above the stream, borings have penetrated to 1,116 feet. At 45 feet depth they entered 20 feet of dark-colored beds containing vegetable remains. Red sandstone was penetrated before reaching 100 feet, and below 130 feet chiefly red beds. Red sand was reported from 584 to 1,116 feet. Rock salt was passed through from 815 to 842 feet; then a few feet of rock, and then 43 feet of rock salt. At the bottom of the boring, or 1,116 feet from the surface, a fine white sand was penetrated, containing pure water, which at first flowed out at the surface, and then fell back 134 feet. Just below the lowest salt bed there is 10 feet of gypsum; also seven feet of gypsum at 1,030 feet, and 10 feet at 1,080 feet. The water rising above the salt becomes saturated and is pumped out and evaporated, and salt of great purity is made. The salt industry is successfully carried on, although as yet the exportations are chiefly confined to Texas.

Two interesting localities in Mitchell county deserve especial mention, where buffaloes have worn paths in the solid rock, showing well-marked foot-prints. One of these is on Lone Wolf creek, four miles west of Colorado City. The path is about a foot wide and nearly ten inches deep; the steps nearly three feet apart, with four inches between the foot-prints. It follows the gentle incline of the rock surface in the dry bed of the creek, and shows that the animals had passed down to the water to drink, and then out on the other prairie beyond, for the tracks all slope one way. The forward wall of the track is higher than the rear, and more abrupt. There are two paths at this place, which are plainly marked for over 100 feet.

Another very interesting place is at the forks of the Champion, seven miles south from Colorado City. Another plainly marked buffalo trail is seen here worn in the solid rock. The slope of the rock is 15° to 25°, and the steps are two feet from centre to centre; the foot-tracks eight inches deep, 14 inches long, and path seven inches wide. This locality is known as the Seven Wells on account of a series of well-marked pot-holes in the sandstone. The two forks of Champion come together here, and just at their junction is a plunge of over 20 feet into a hole 25 feet wide. The other pot-holes are situated just within the forks of the stream, and are of various sizes, varying from six to eight and ten feet across, with others of smaller size, and are mostly full of water and are over 10 feet deep, and one is reported to be over 50 feet deep. There is no doubt but some are over 25 feet deep, but I did not have the means of measuring their depths. They are of greater diameter below than at the top, and are worn very smooth upon the sides. All of them contain gravel, and some are nearly filled

with it, while it is being continually borne along in the stream, which is very rapid when full. The quartz and flinty gravel is the erosive agent, and the water the power.

From Fort Worth westward the surface of the country gradually ascends above the sea level. Fort Worth is 623 feet above the sea, Weatherford is 864 feet, with the lower (Gulf) Cretaceous occupying the surface at both places, with lower strata at Weatherford than at Fort Worth. Westwardly the Brazos cuts into the "Red beds" on the east, and on the west the rocks of the upper Coal Measures appear and are seen nearly as far west as Cisco, which is 1,611 feet above the sea. West of Cisco the country still gradually rises, with occasional Cretaceous outliers. Colorado City is over 1,800 feet above the sea, with the red beds as the most prominent rock. This indicates an anticlinal axis not far from Cisco, and a synclinal between Colorado and El Paso not far, probably, from the latter place.

Salt Deposits. The borings for salt penetrated and probably passed the Jura-Trias into the Permian, to which latter the strata below 800 feet depth from the surface may belong. At Kingman, Kansas, the surface formation is about the summit of the Permian; at 750 feet depth rock salt was reached.

At Hutchison, Kansas, under a similar surface formation, the borings gave as follows:

1. One hundred and ten feet of sand, gravel and clay.
2. Three hundred and fifteen feet of red and black shale with gypsum.

At 425 feet depth salt, extending to 715 feet, including 25 feet of shales occurring in thin layers three, eight and ten feet apart. The salt water remains below 210 feet from the surface.

A boring at Lyons, Kansas, reports—

1. Two hundred feet of drift.
2. Two hundred and thirty feet of red shale.
3. Two hundred and seventy feet of shale and gypsum.
4. Thirty-five feet of black shale.
5. Sixty-five feet of gray shale.
6. Salt at 800 feet depth.

Near Blue Rapids, Kansas, salt water was obtained in Permian beds at 317 feet from the surface, the water rising within 20 feet of the surface.

At Ellsworth, Kansas, where the surface rocks are the Dakota Cretaceous, rock salt was reached at 740 feet depth. Passing through 160 feet of salt, shale was penetrated, and at 1,100 feet gas obtained. The lower beds are Permian.

Rock salt has been obtained in borings at other places in Kansas, generally mixed with shale.

The geological position of most of the salt beds of Kansas and Texas is in the Permian. There are also probably other deposits occupying basins of more recent age, as the Spirit spring near Cawker City, Kansas.

University of Missouri. G. C. BROADHEAD.

The literature of geyserite. It is difficult to understand why Dr. Hicks, in his notes on the "Geyserite deposits of Nebraska," as given in the GEOLOGIST for May and July, should have ignored the literature of the subject. As long ago as April, 1885, the present writer published in the

Proceedings of the U. S. National Museum (vol. viii, p. 99) a short paper, calling attention to the fact that certain deposits of fine white and gray dust located in Harlan and Furnas counties, Nebraska, and along the Republican river, extending into Kansas, and locally known as geyserite, were composed almost wholly of finely-comminuted pumice dust. Again, in the *Am. Jour. of Sci.* for September, 1886 (pp. 199–204), under the title of *Notes on the composition of certain Pliocene sandstone from Montana and Idaho*, the writer called attention to the fact that the fine-grained, light-colored and friable arenaceous rocks collected in 1871 by Dr. A. C. Peale, of the U. S. Geological Survey (F. V. Hayden in charge), were of a similar nature. In this latter paper particular care was taken to bring together in such form as to be available a number of references to the occurrence of these beds, not only in Montana and Idaho, but also Nebraska, Kansas, eastern Colorado and Dakota. Both papers were accompanied by figures, showing the appearance of the dust as seen under the microscope, and the second also gave results of three chemical analyses on the Montana and Idaho samples.

Since these papers were written, the writer has had an opportunity of personally inspecting the beds in Montana and Nebraska, and has not the slightest hesitancy in re-affirming his opinion that the deposits are of volcanic origin, *i. e.*, are made up of volcanic dust (pumiceous) and sand, and owe their present purity and evenly stratified condition to the assorting agencies of water and atmospheric currents.

To this same conclusion Dr. Hicks, aided by the U. S. geological survey, seems now to be coming gradually. That Prof. Aughey should, at the time he wrote, have failed to fully understand the nature of the scales, is not at all strange. At the present time it is, however, difficult to understand how any one familiar with the nature of chemical precipitates, or ejected volcanic materials, can for a moment hesitate regarding the true nature of the beds in question. GEORGE P. MERRILL.

U. S. Nat. Mus. Washington, July 30, 1888.

Note on Mr. Merrill's Letter. The "literature of the subject" is not limited to the contributions of Mr. Merrill, as one might infer from the above letter from him. Interesting and important as his two papers are, we must credit another writer with the first correct account of the deposit in question. Dr. M. E. Wadsworth described specimens collected by Mr. Samuel Gorman between the White and Niobrara rivers (Lithological Studies, November, 1884, p. 17). It is "difficult to understand" why Mr. Merrill "ignores" that account, which has priority over his own.

For my part, instead of ignoring the literature of the subject, I have given fresh currency to a very unique portion of it. Prof. Aughey's explanation of this flour-like earth is the earliest of all. Though erroneous, as I intimated in the May number of the GEOLOGIST that it might be, his vision of Nebraska in tertiary times as "a great geyser region, far exceeding in the number and magnitude of its geysers the Yellowstone region and Iceland at the present day," is too vivid and picturesque to be allowed to fade into oblivion. I am indebted to Mr. J. S. Diller for calling my attention to Wadsworth's paper, as well as for specimens communicated and many other courtesies. L. E. HICKS.

PERSONAL AND SCIENTIFIC NEWS.

The Brooklyn Institute, N. Y. One of the earliest courses of popular lectures delivered by professor Louis Agassiz on his arrival in America was presented at the Brooklyn Institute. In succeeding times its fortunes have fluctuated; but with reorganization and strengthening of resources a new era of activity began in 1887. By provision of the founder, series of popular scientific lectures are delivered during the winter months. Some of the lectures for 1888-9 are the following: Prof. Darwin G. Eaton, on *Volcanoes;* Prof. William O. Atwater on *The Chemistry of Foods;* Prof. G. Frederick Wright, on *The Glaciers of Alaska and the Ice Age;* William H. Niles, on *Mountain Sculpture;* Major J. W. Powell, on *Human Evolution;* Rev. Dr. Charles H. Hall, on *The Yellowstone Park;* Prof. G. Brown Goode, on *The Museums of the Future.*

Prof. H. S. Williams has recently called attention in *Science* for Nov. 16, 1888, to a "remarkably clear conception of the elements of the theory for which Darwin has become famous" published almost thirty years prior to the appearance of "The Origin of Species." It is by Robert Bakewell, and is found in his "Introduction to Geology," published in 1833. The chief points of Darwin's theory of the origin of species are here expressed. They are founded also upon observed facts.

Prof. Robt. T. Hill in *Science* reports that two hundred head or more of buffaloes may be found in the Panhandle of Texas, on the Llano Estacado, and in No-Man's Land. Some are on the Palo Duro Canon ranch, owned by captain Charles Goodnight; others in the Texas Capital Syndicate, on xii pasture, especially on the North Plains, *i.e.* north of the Canadian river; still others are at large. There are also many on the South Plain.

A herd of eighty-three live buffaloes recently passed through Minneapolis, transported by cars from Warden Benson's, in Northwest territory, to C. J. Jones' ranch near Garden City, Kansas, where about fifty more head are preserved, and a goodly number of animals resulting from cross between the bison and the ordinary beef cattle.

Since the publication of the report of state geologist Branner, of Arkansas, on the mining industry of that state, showing the valueless nature of many of the so-called mines, particularly those of the Hot Springs district, Prof. Branner has been subjected to bitter and vindictive abuse from the mine-owners of that region—such as was never poured upon a public officer, even among politicians. With dignified candor and undisturbed confidence Prof. Branner has offered to submit the main question at issue to eleven expert mining engineers and geologists, and has promised to publish their report in his next official report to the governor, whatever the decision may be.

MAJOR J. W. POWELL, DIRECTOR U. S. G. S., has called a conference "of those officers of the western states and territories whose duties include the supervision of matters relating to irrigation and water rights" to meet with him in Denver, the first week in December. This is in consequence of the Congressional appropriation for the location of sites for reservoirs for irrigation, a matter of national importance. Dr. L. E. Hicks attends this conference on behalf of the State of Nebraska.

IN EXCAVATING A WELL ON ANTELOPE CREEK for the city of Lincoln, Neb., the laborers found a bone which proves to be the first phalanx of the right outer hind toe of *Bison latifrons* Leidy. It is about one-third larger than the corresponding bone in the skeleton of a cow in the cabinet of the University of Nebraska, as will be seen from the following measurements:

	Bison latifrons.	Bos.
Length of first phalanx	3¼ inches.	2½ inches.
Circumference, upper end	5¼ "	4⅛ "
Circumference, lower "	4½ "	3¼ "

The section of the well is as follows:

9.	Soil	1 foo
8.	Buff colored clay, containing shells of fresh water mollusca (Loess)	12 feet
Glacial Drift.	7. Bluish clay, with some pebbles and ferruginous streaks	5 "
	6. Yellow sand, with quartzyte boulders	5 "
	5. Red clay	6 "
	4. Sand	8 "
	3. Clay	5 "
	2. Gravel	5 "
1.	Sandstone (Dakota gr. Cretacic)	31 "
	Total	78 feet

The lower part of this section is from another well a few feet away, the large well (20 ft. in diameter) not being finished. The specimen was found in the yellow sand, No. 6 belonging to the glacial drift. It is slightly rolled and worn, but could not have been carried far by the ice without greater abrasion than it exhibits.

ERRATA.

Page 180, 27th line, for "igneous veins chrysolite, etc.," read *aqueous veins chrysotile.*
" 347, 38th line, for "placid" read glacial.
" 379, 4th line from the bottom, for "ice-man" read ice-mass.
" 308, 12th line, for "proprietors" read progenitors.

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The American Geologist, Prospectus for 1889.

The editors of *The American Geologist* announce the continuance of the periodical during the year 1889, under the same general plan as in the past. The leading purpose is to give expression to American thought on geological themes, and to offer a medium of ready communication for educational, biographical and bibliographical information, and geological news.

They hope the working geologists of the country will continue to favor it with their interest and co-operation, and will bear in mind the fact that no other journal on the continent devotes its entire means and energies to an adequate representation of the science which brings all other sciences under contribution. The editors hope *The Geologist* will become generally recognized as the organ of geological opinion and interests in America; and that briefer memoirs and items, especially those not designed for final publication, may be directed to its pages for presentation to the public.

It is the editors' intention, also, to continue and improve the treatment of geological themes connected with education. They have not yet been able to accomplish all which has been in intention from the beginning; but the purpose is to embrace under educational topics the discussion of questions relating to the place of Geology in Education; the exhibition of methods and devices for the presentation of geologic facts and doctrines, and the description and illustration of the scientific resources of leading Universities—especially those of the West, as being least known. In respect to geological biography, it is intended to offer brief memoirs accompanied by portraits, commemorative of deceased geologists who have done worthy service for science. In geological bibliography the editors still hope to supply information somewhat full and complete, together with critical notices and reviews of the most noteworthy publications.

The Geologist appeals for support to the intelligence of America; especially to those able to devote some time to geological reading; to those interested in the teaching of Geology and in the advancement of geological instruction in the schools. The editors hope the list of subscribers may be largely recruited with the beginning of the second year; and they beg each old subscriber to constitute himself an agent for the procurement of a new name.

With three hundred working geologists in the country, as there are, and many thousand intelligent readers of geological literature, the editors confidently anticipate a noble support for the only literary representative of geological learning and interests in the journalism of America.

The subscription price will be $3.50 per year in America, and $3.75 in foreign countries of the *Postal Union*. The general European agent is Mr. W. P. Collins, 157 Great Portland st., London W., England. Correspondence may be addressed to any of the editors, or to

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